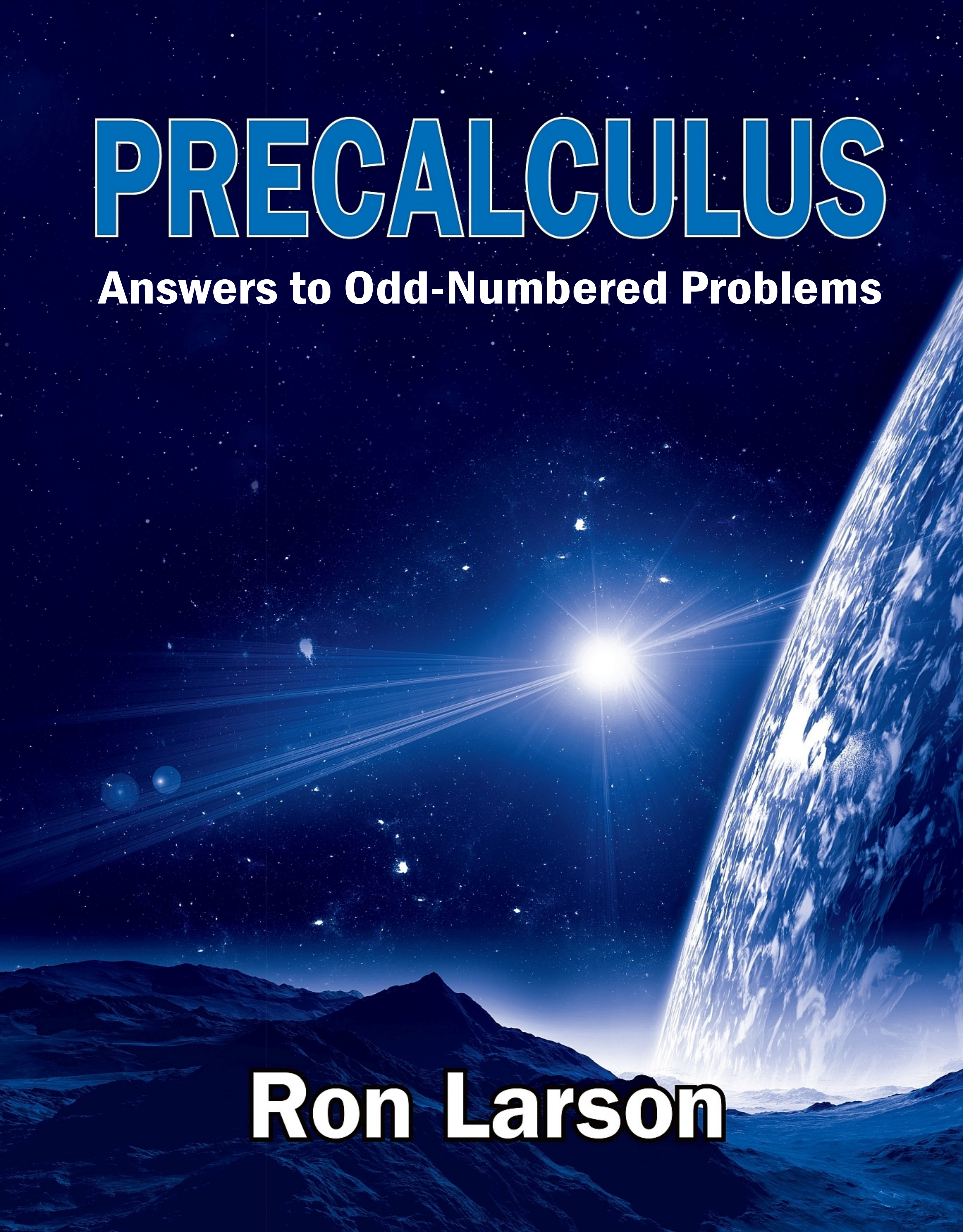
PRECALCULUS

Answers to Odd-Numbered Problems



Ron Larson

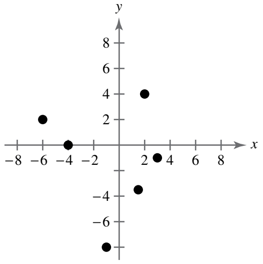
Answers to Odd-Numbered Exercises and Tests

Chapter 1

Section 1.1 *(page 8)*

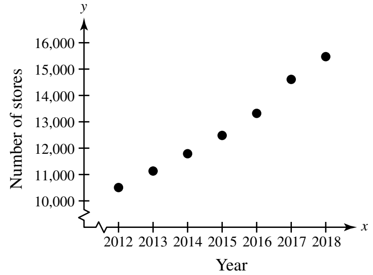
1. Cartesian **3.** c **4.** f **5.** a **6.** d **7.** e
8. b **9.** A: (2, 6), B: (−6, −2), C: (4, −4), D: (−3, 2)

11.



13. (−3, 4) **15.** Quadrant IV
17. Quadrant II **19.** Quadrant II or IV

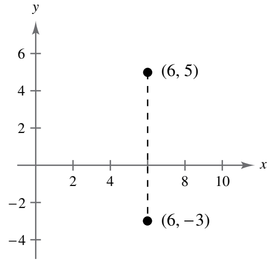
21.



23. 13 **25.** $\sqrt{61}$ **27.** $\dfrac{\sqrt{277}}{6}$

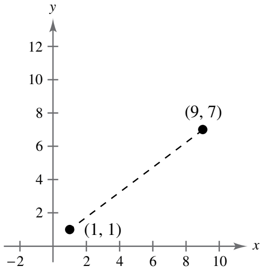
29. (a) 5, 12, 13 (b) $5^2 + 12^2 = 13^2$
31. $(\sqrt{5})^2 + (\sqrt{45})^2 = (\sqrt{50})^2$
33. Distances between the points: $\sqrt{29}$, $\sqrt{58}$, $\sqrt{29}$

35. (a)



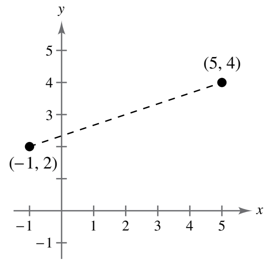
(b) 8 (c) (6, 1)

37. (a)



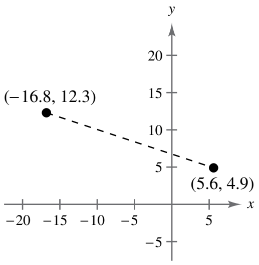
(b) 10 (c) (5, 4)

39. (a)



(b) $2\sqrt{10}$
(c) (2, 3)

41. (a)



(b) $\sqrt{556.52}$
(c) (−5.6, 8.6)

43. $2\sqrt{505} \approx 45$ yd **45.** $500.15 billion
47. (0, 1), (4, 2), (1, 4) **49.** (−3, 6), (2, 10), (2, 4), (−3, 4)
51. True. Because $x < 0$ and $y > 0$, $2x < 0$ and $-3y < 0$, which is located in Quadrant III.
53. True. Two sides of the triangle have lengths of $\sqrt{149}$, and the third side has a length of $\sqrt{18}$.
55. Point on x-axis: $y = 0$; Point on y-axis: $x = 0$
57. $(2x_m - x_1, 2y_m - y_1)$
59. Use the Midpoint Formula to prove that the diagonals of the parallelogram bisect each other.

$$\left(\frac{b+a}{2}, \frac{c+0}{2}\right) = \left(\frac{a+b}{2}, \frac{c}{2}\right)$$

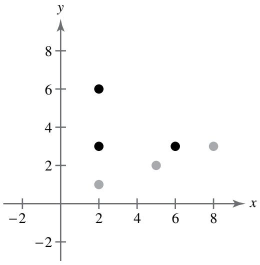
$$\left(\frac{a+b+0}{2}, \frac{c+0}{2}\right) = \left(\frac{a+b}{2}, \frac{c}{2}\right)$$

60. (a) ii (b) iii (c) iv (d) i

61. (a)

	First Set	Second Set
Distance A to B	3	$\sqrt{10}$
Distance B to C	5	$\sqrt{10}$
Distance A to C	4	$\sqrt{40}$
	Right triangle	Isosceles triangle

(b)



The first set of points is not collinear. The second set of points is collinear.

(c) A set of three points is collinear when the sum of two distances among the points is exactly equal to the third distance.

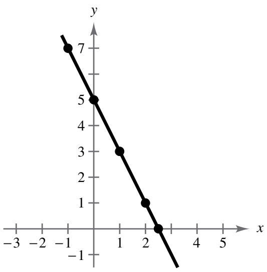
63. (a) −10 (b) −6 **65.** (a) −54 (b) 0 **67.** $x^2 - 2$
69. 0 **71.** (a) $P = 42x - 35{,}000$ (b) $175,000

Section 1.2 *(page 19)*

1. solution or solution point **3.** intercepts
5. origin **7.** Algebraic, graphical
9. (a) Yes (b) No **11.** (a) No (b) Yes

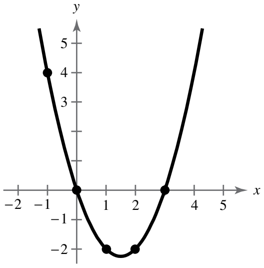
13.

x	−1	0	1	2	$\frac{5}{2}$
y	7	5	3	1	0
(x, y)	(−1, 7)	(0, 5)	(1, 3)	(2, 1)	$(\frac{5}{2}, 0)$



15.

x	-1	0	1	2	3
y	4	0	-2	-2	0
(x, y)	$(-1, 4)$	$(0, 0)$	$(1, -2)$	$(2, -2)$	$(3, 0)$



17. x-intercept: $(-2, 0)$
y-intercept: $(0, 2)$

19. x-intercept: $(3, 0)$
y-intercept: $(0, 9)$

21. x-intercept: $\left(\frac{6}{5}, 0\right)$
y-intercept: $(0, -6)$

23. x-intercept: $(-4, 0)$
y-intercept: $(0, 2)$

25. x-intercept: $\left(\frac{7}{3}, 0\right)$
y-intercept: $(0, 7)$

27. x-intercepts: $(0, 0)$, $(2, 0)$
y-intercept: $(0, 0)$

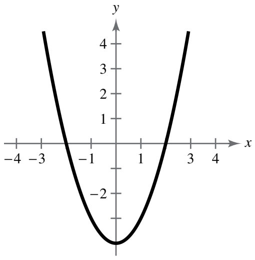
29. y-axis symmetry

31. Origin symmetry

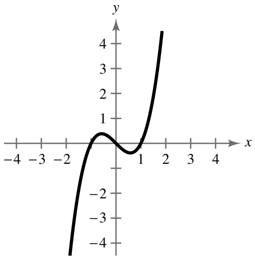
33. Origin symmetry

35. x-axis symmetry

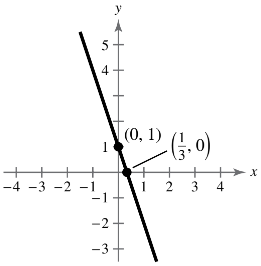
37.



39.

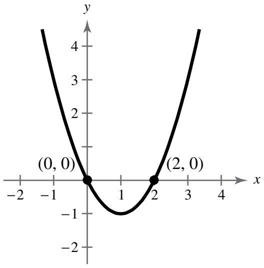


41. No symmetry



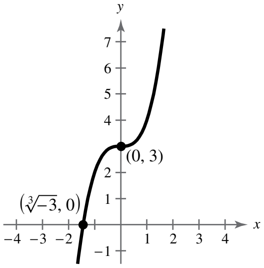
x-intercept: $\left(\frac{1}{3}, 0\right)$
y-intercept: $(0, 1)$

43. No symmetry



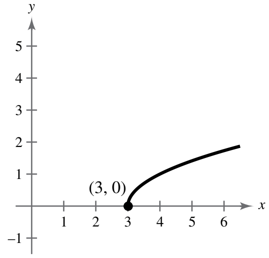
x-intercepts: $(0, 0)$, $(2, 0)$
y-intercept: $(0, 0)$

45. No symmetry



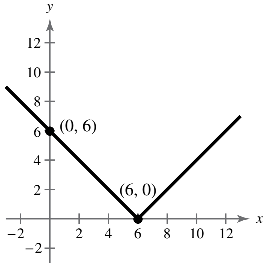
x-intercept: $\left(\sqrt[3]{-3}, 0\right)$
y-intercept: $(0, 3)$

47. No symmetry



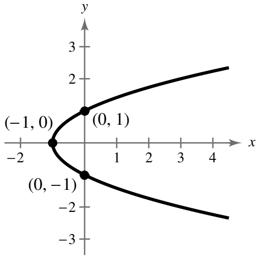
x-intercept: $(3, 0)$
y-intercept: None

49. No symmetry



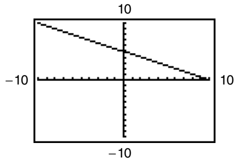
x-intercept: $(6, 0)$
y-intercept: $(0, 6)$

51. x-axis symmetry



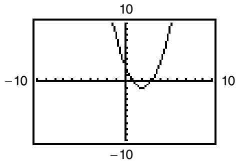
x-intercept: $(-1, 0)$
y-intercepts: $(0, \pm 1)$

53.



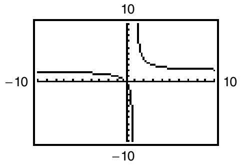
Intercepts: $(10, 0)$, $(0, 5)$

55.



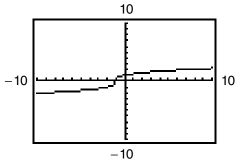
Intercepts:
$(3, 0)$, $(1, 0)$, $(0, 3)$

57.



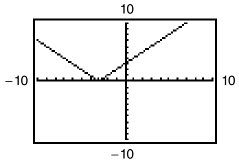
Intercept: $(0, 0)$

59.



Intercepts: $(-1, 0)$, $(0, 1)$

61.



Intercepts: $(-3, 0)$, $(0, 3)$

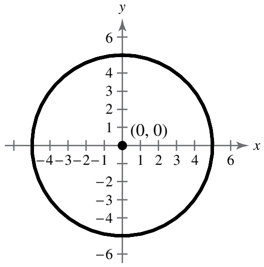
63. $x^2 + y^2 = 9$

65. $(x + 4)^2 + (y - 5)^2 = 4$

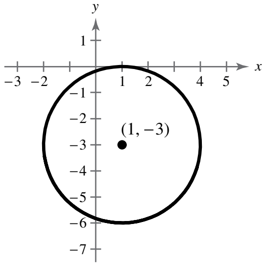
67. $(x - 3)^2 + (y - 8)^2 = 169$

69. $(x + 3)^2 + (y + 3)^2 = 61$

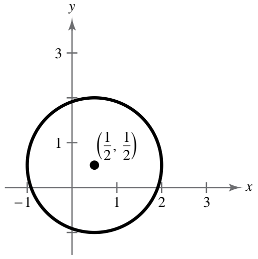
71. Center: $(0, 0)$; Radius: 5



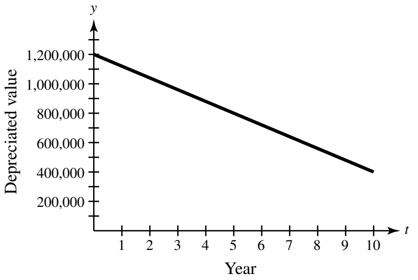
73. Center: $(1, -3)$; Radius: 3



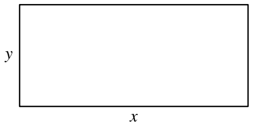
75. Center: $\left(\frac{1}{2}, \frac{1}{2}\right)$; Radius: $\frac{3}{2}$



77.

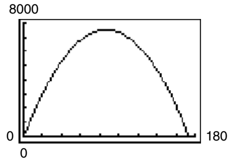


79. (a)



(b) Answers will vary.

(c)



(d) $x = 86\frac{2}{3}, y = 86\frac{2}{3}$

(e) A regulation NFL playing field is 120 yards long and $53\frac{1}{3}$ yards wide. The actual area is 6400 square yards.

81. False. $y = x$ is symmetric with respect to the origin.

83. When replacing y with $-y$ yields an equivalent equation, the graph is symmetric with respect to the x-axis.

85. (a) $a = 1, b = 0$ (b) $a = 0, b = 1$

87. $21x + 3$ **89.** $6x - 2$ **91.** 12 **93.** $x - 4$

95. $27\sqrt{2}$ **97.** 823,543 **99.** $2x^2 + 8x + 11$

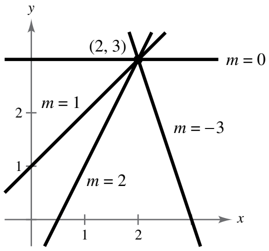
101. $2x^2 - 5x - 63$

Section 1.3 *(page 31)*

1. linear **3.** point-slope **5.** rate or rate of change

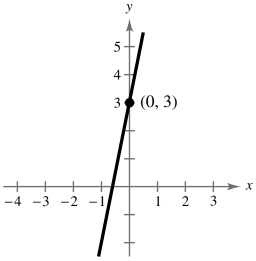
7. They are perpendicular. **9.** (a) L_2 (b) L_3 (c) L_1

11.

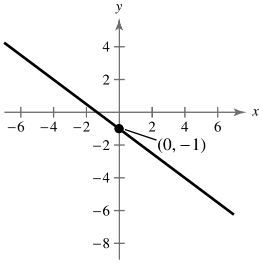


13. $\frac{3}{2}$

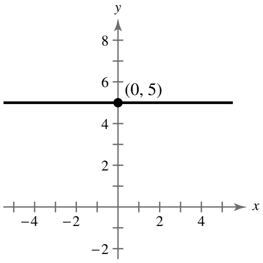
15. $m = 5$
y-intercept: $(0, 3)$



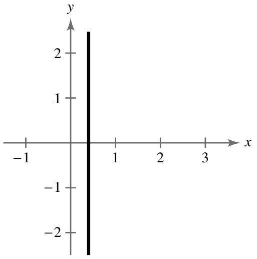
17. $m = -\frac{3}{4}$
y-intercept: $(0, -1)$



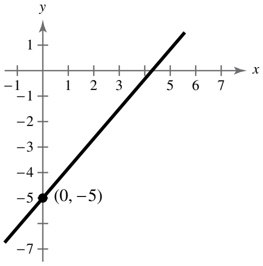
19. $m = 0$
y-intercept: $(0, 5)$



21. m is undefined.
y-intercept: none



23. $m = \frac{7}{6}$
y-intercept: $(0, -5)$



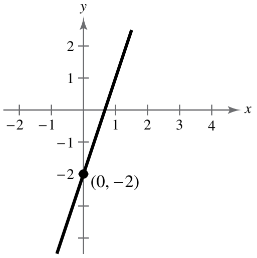
25. $m = -\frac{3}{2}$ **27.** $m = 2$ **29.** $m = 0$

31. m is undefined. **33.** $m = 0.15$

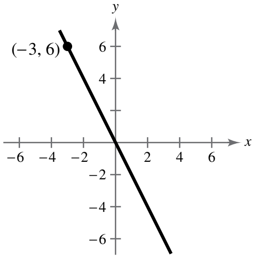
35. $(-1, 7), (0, 7), (4, 7)$ **37.** $(-4, 6), (-3, 8), (-2, 10)$

39. $(-2, 7), \left(0, \frac{19}{3}\right), (1, 6)$ **41.** $(-4, -5), (-4, 0), (-4, 2)$

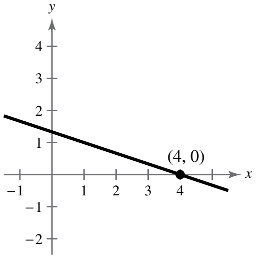
43. $y = 3x - 2$



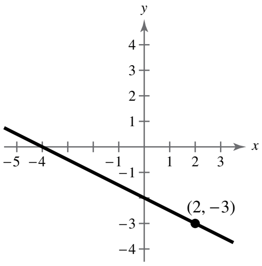
45. $y = -2x$



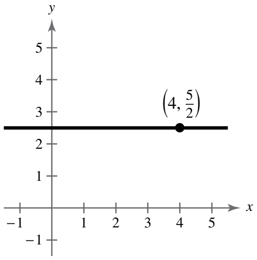
47. $y = -\frac{1}{3}x + \frac{4}{3}$



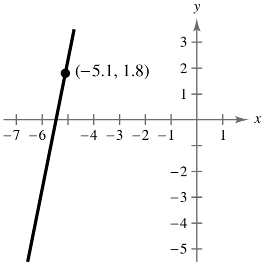
49. $y = -\frac{1}{2}x - 2$



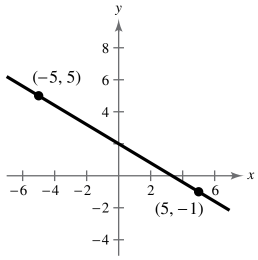
51. $y = \frac{5}{2}$



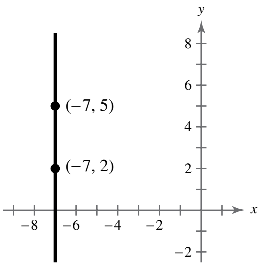
53. $y = 5x + 27.3$



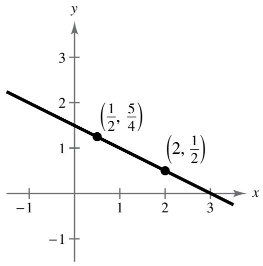
55. $y = -\frac{3}{5}x + 2$



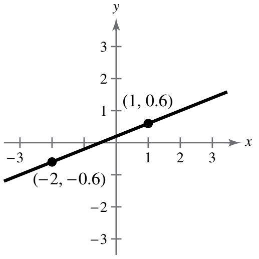
57. $x = -7$



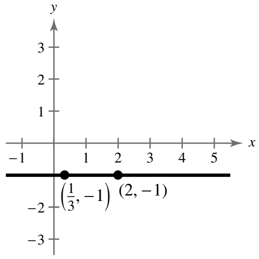
59. $y = -\frac{1}{2}x + \frac{3}{2}$



61. $y = 0.4x + 0.2$



63. $y = -1$



65. Parallel **67.** Neither **69.** Perpendicular

71. Parallel **73.** (a) $y = 2x - 3$ (b) $y = -\frac{1}{2}x + 2$

75. (a) $y = -\frac{3}{4}x + \frac{3}{8}$ (b) $y = \frac{4}{3}x + \frac{127}{72}$

77. (a) $y = 4$ (b) $x = -2$

79. (a) $y = x + 4.3$ (b) $y = -x + 9.3$

81. $5x + 3y - 15 = 0$ **83.** $12x + 3y + 2 = 0$

85. $x + y - 3 = 0$

87. (a) Sales increasing 135 units/yr
(b) No change in sales
(c) Sales decreasing 40 units/yr

89. 12 ft

91. $F = 1.8C + 32$ or $C = \frac{5}{9}F - \frac{160}{9}$

93. $V = -166t + 830, 0 \le t \le 5$

95. (a) $C = 21t + 42{,}000$ (b) $R = 45t$
(c) $P = 24t - 42{,}000$ (d) 1750 h

97. False. The slope with the greatest magnitude corresponds to the steepest line.

99. Find the slopes of the lines containing each two points and use the relationship $m_1 = -\dfrac{1}{m_2}$.

101. (a) The slope is $\frac{1}{2}$, not 2.
(b) The y-intercept is -3, not 4.

103. The line $y = 4x$ rises most quickly, and the line $y = -4x$ falls most quickly. The greater the magnitude of the slope (the absolute value of the slope), the faster the line rises or falls.

105. 6; 0; 6; 30 **107.** $\frac{3}{2}$; $\frac{7}{10}$; -2; $-\frac{209}{10}$ **109.** $\pm 1, \dfrac{5}{2}$

111. $-\sqrt[3]{5}, 1$ **113.** 50 **115.** $-1, 2$

117. No real solution **119.** $\dfrac{-2x + 1}{x}$ **121.** $x^2 + 3, x \neq 1$

Section 1.4 *(page 44)*

1. independent; dependent

3. A relation is a rule of correspondence between an input and an output. A function is a relation in which each input is matched with exactly one output.

5. Explicitly described **7.** Function **9.** Not a function

11. (a) Function (b) Function
(c) Not a function, because not every element in A is matched with an element in B.

13. Not a function **15.** Function **17.** Function

19. Function **21.** (a) 15 (b) 12 (c) $4t^2 + 13t + 15$

23. (a) 1 (b) 2.5 (c) $3 - 2|x|$

25. (a) $-\dfrac{1}{9}$ (b) Undefined (c) $\dfrac{1}{y^2 + 6y}$

27. (a) 1 (b) -1 (c) $\dfrac{|x - 1|}{x - 1}$

29. (a) -1 (b) 2 (c) 6

31.

x	-2	-1	0	1	2
$f(x)$	1	4	5	4	1

33.

x	-2	-1	0	1	2
$f(x)$	5	$\frac{9}{2}$	4	1	0

35. 5 **37.** $\frac{4}{3}$ **39.** ± 9 **41.** $0, \pm 1$ **43.** $-1, 2$

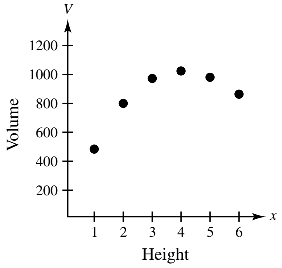
45. $0, \pm 2$ **47.** All real numbers x

49. All real numbers y such that $y \ge -6$

51. All real numbers x except $x = 0, -2$

53. All real numbers s such that $s \ge 1$ except $s = 4$

55. (a) The maximum volume is 1024 cubic centimeters.
(b)



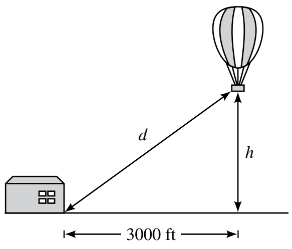
Yes, V is a function of x; $V = x(24 - 2x)^2$, $0 < x < 12$

57. No, the ball will be at a height of 18.5 feet.

59. $A = \dfrac{a^2}{2(a - 2)}$, $a > 2$

61. 2012: 79.42%
2013: 81.18%
2014: 82.94%
2015: 84.70%
2016: 85.90%
2017: 86.80%
2018: 87.70%

63. (a)



(b) $h = \sqrt{d^2 - 3000^2}$, $d \ge 3000$

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65. (a) $C = 12.30x + 98{,}000$ (b) $R = 17.98x$
(c) $P = 5.68x - 98{,}000$

67. (a) $R = \dfrac{240n - n^2}{20}, \quad n \geq 80$

(b)

n	90	100	110	120	130	140	150
$R(n)$	\$675	\$700	\$715	\$720	\$715	\$700	\$675

The revenue is maximum when 120 people take the trip.

69. $2 + h, \quad h \neq 0$ **71.** $3x^2 + 3xh + h^2 + 3, \quad h \neq 0$

73. $-\dfrac{x + 3}{9x^2}, \quad x \neq 3$ **75.** $\dfrac{\sqrt{5x} - 5}{x - 5}$

77. False. A function is a special type of relation.

79. False. The range is $[-1, \infty)$.

81. $g(x) = cx^2; c = -2$ **83.** $r(x) = \dfrac{c}{x}; c = 32$

85. The domain of $f(x)$ includes $x = 1$ and the domain of $g(x)$ does not because you cannot divide by 0. So, the functions do not have the same domain.

87. No; x is the independent variable, f is the name of the function.

89. $\pm 1, 3$ **91.** $-5, \frac{3}{2}$

93. x-intercepts: $(-2, 0), (1, 0)$ y-intercept: $(0, -2)$

95. $(0, 0), \left(\frac{3}{2}, 0\right), (6, 0)$ **97.** $(1.17, 0), (2.44, 0)$

99. 4 **101.** $-\frac{1}{12}$ **103.** 12

Section 1.5 *(page 56)*

1. zeros **3.** average rate of change; secant **5.** No

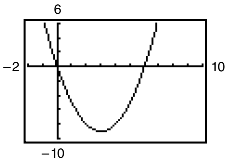
7. Domain: $[-2, 2]$; range: $[-1, 8]$
(a) -1 (b) 0 (c) -1 (d) 8

9. Domain: $(-\infty, \infty)$; range: $(-2, \infty)$
(a) 0 (b) 1 (c) 2 (d) 3

11. Function **13.** Not a function **15.** $-\frac{5}{2}, 6$

17. $0, \pm\sqrt{6}$ **19.** $\pm 3, 4$ **21.** $\frac{1}{2}$ **23.** ± 1 **25.** -3

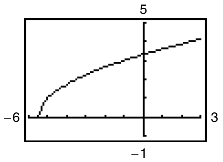
27. (a)



0, 6

(b) 0, 6

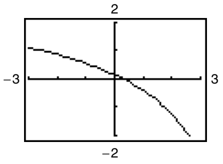
29. (a)



-5.5

(b) $-\frac{11}{2}$

31. (a)



0.3333

(b) $\frac{1}{3}$

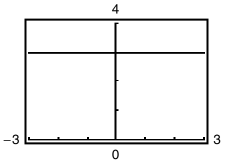
33. Decreasing on $(-\infty, \infty)$

35. Increasing on $(1, \infty)$; Decreasing on $(-\infty, -1)$

37. Increasing on $(1, \infty)$; Decreasing on $(-\infty, -1)$
Constant on $(-1, 1)$

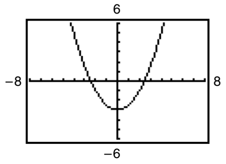
39. Increasing on $(-\infty, -1), (0, \infty)$; Decreasing on $(-1, 0)$

41.



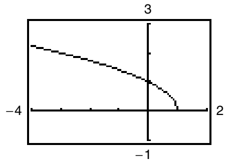
Constant on $(-\infty, \infty)$

43.



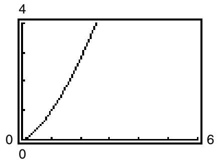
Decreasing on $(-\infty, 0)$
Increasing on $(0, \infty)$

45.



Decreasing on $(-\infty, 1)$

47.



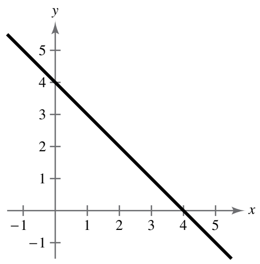
Increasing on $(0, \infty)$

49. Relative minimum: $(-1.5, -2.25)$

51. Relative maximum: $(0, 15)$
Relative minimum: $(4, -17)$

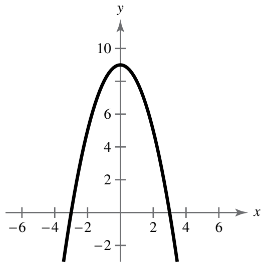
53. Relative minimum: $(0.33, -0.38)$

55.



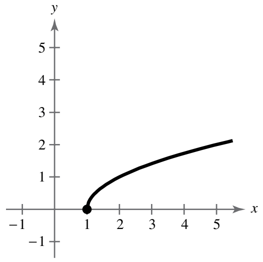
$(-\infty, 4]$

57.



$[-3, 3]$

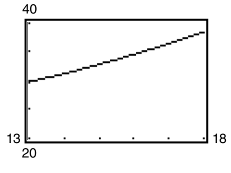
59.



$[1, \infty)$

61. -2 **63.** -1

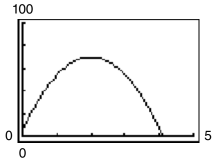
65. (a)



(b) About 1.73; The amount the U.S. federal government spent on applied research increased by about \$1.73 billion each year from 2013 to 2018.

67. (a) $s = -16t^2 + 64t + 6$

(b)

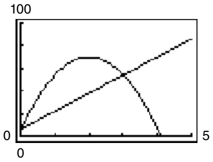


(c) 16 ft/sec

(d) The slope of the secant line is positive.

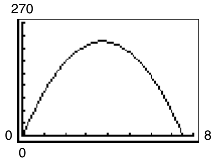
(e) $y = 16t + 6$

(f)



69. (a) $s = -16t^2 + 120t$

(b)

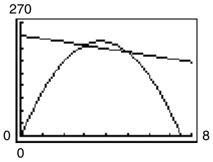


(c) -8 ft/sec

(d) The slope of the secant line is negative.

(e) $y = -8t + 240$

(f)

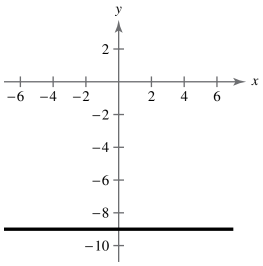


71. Even; y-axis symmetry

73. Neither; no symmetry

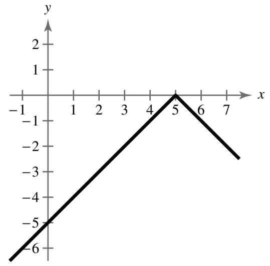
75. Neither; no symmetry

77.



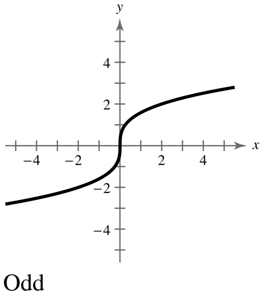
Even

79.



Neither

81.

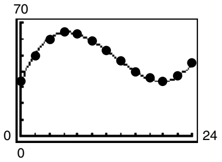


Odd

83. $h = 3 - 4x + x^2$

85. $L = 2 - \sqrt[3]{2y}$

87. (a)



(b) The model fits the data very well.

(c) The temperature was increasing from 6 A.M. ($x = 0$) to noon ($x = 6$), and again from 2 A.M. ($x = 20$) to 6 A.M. ($x = 24$). The temperature was decreasing from noon to 2 A.M.

(d) The maximum temperature was 63.93°F and the minimum temperature was 33.98°F.

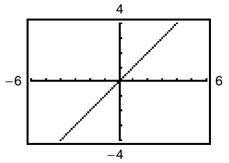
(e) Answers will vary.

89. False. The function $f(x) = \sqrt{x^2 + 1}$ has a domain of all real numbers.

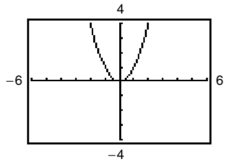
91. The negative symbol should be divided out of each term, which yields $f(-x) = -(2x^3 + 5)$. So, the function is neither even nor odd.

93. (a) $\left(\frac{5}{3}, -7\right)$ (b) $\left(\frac{5}{3}, 7\right)$

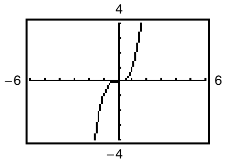
95. (a)



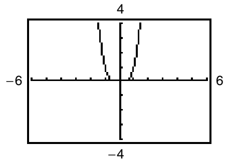
(b)



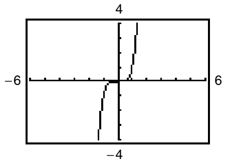
(c)



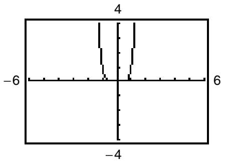
(d)



(e)

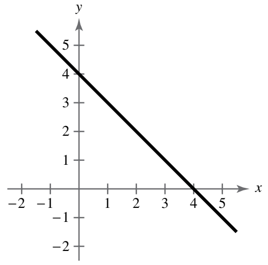


(f)

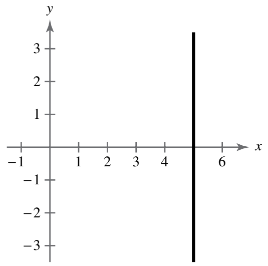


All the graphs pass through the origin. The graphs of the odd powers of x are symmetric with respect to the origin, and the graphs of the even powers are symmetric with respect to the y-axis. As the powers increase, the graphs become flatter in the interval $-1 < x < 1$.

97. $y = -x + 4$



99. $x = 5$



101. (a) -18 (b) 12 (c) $5x + 12$

103. (a) 3 (b) 5 (c) 2

105. $2n + 1$

Section 1.6 *(page 65)*

1. Greatest integer function

3. Reciprocal function

5. Square root function

7. Absolute value function

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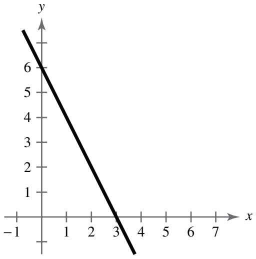
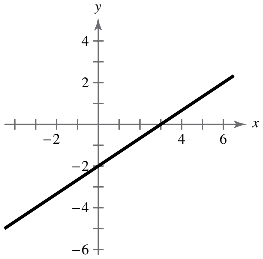
9. Linear function

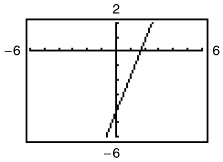
11. (a) $f(x) = -2x + 6$
(b)



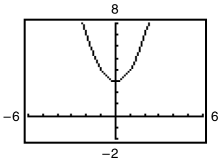
13. (a) $f(x) = \frac{2}{3}x - 2$
(b)



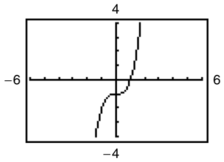
15.



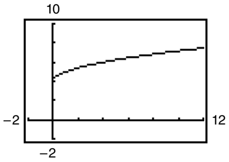
17.



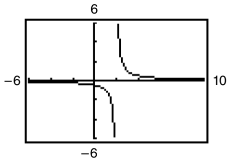
19.



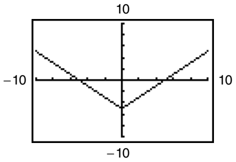
21.



23.



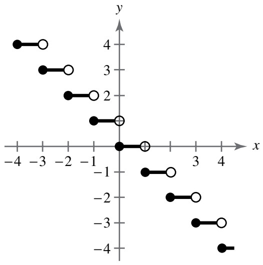
25.



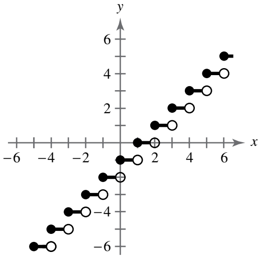
27. (a) 2 (b) 2 (c) −4 (d) 3

29. (a) 1 (b) −4 (c) 3 (d) 2

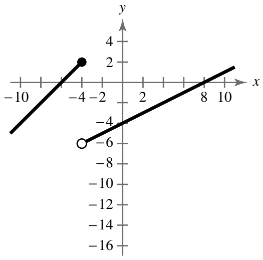
31.



33.



35.



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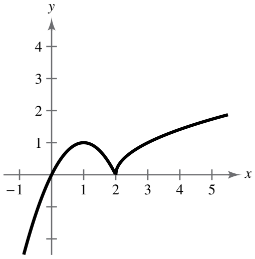
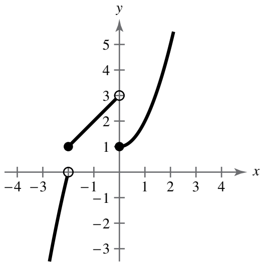
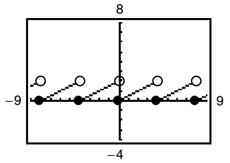


39.



41. (a)



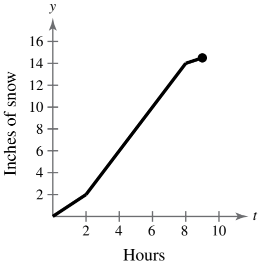
(b) Domain: $(-\infty, \infty)$
Range: $[0, 2)$

43. (a) $W(30) = 420$; $W(40) = 560$; $W(45) = 665$; $W(50) = 770$

(b) $W(h) = \begin{cases} 14h, & 0 < h \le 36 \\ 21(h - 36) + 504, & h > 36 \end{cases}$

(c) $W(h) = \begin{cases} 16h, & 0 < h \le 40 \\ 24(h - 40) + 640, & h > 40 \end{cases}$

45. $f(t) = \begin{cases} t, & 0 \le t \le 2 \\ 2t - 2, & 2 < t \le 8 \\ \frac{1}{2}t + 10, & 8 < t \le 9 \end{cases}$



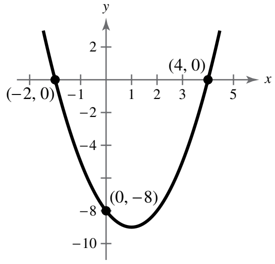
Total accumulation = 14.5 in.

47. False. A piecewise-defined function is a function that is defined by two or more equations over a specified domain. That domain may or may not include x- and y-intercepts.

49. The domains should be $x \le 3$ and $x > 3$.

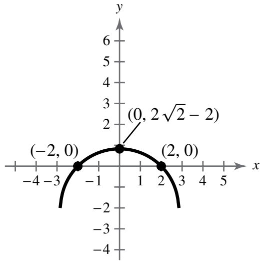
51. (a) Yes. The amount that you pay in sales tax will increase as the price of the item purchased increases.
(b) No. The length of time that you study the night before an exam does not necessarily determine your score on the exam.

53.



x-intercepts: $(-2, 0), (4, 0)$
y-intercept: $(0, -8)$

55.



x-intercepts:
$(-2, 0), (2, 0)$
y-intercept: $(0, 2\sqrt{2} - 2)$

57. $-\dfrac{\sqrt[3]{x^2} - \sqrt[3]{x}}{x}$ **59.** $x^2 - 9x + 20$

Section 1.7 *(page 72)*

1. $-f(x); f(-x)$

3. Horizontal shifts, vertical shifts, reflections

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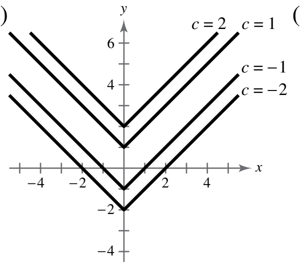
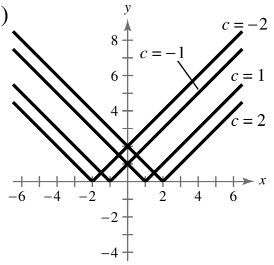
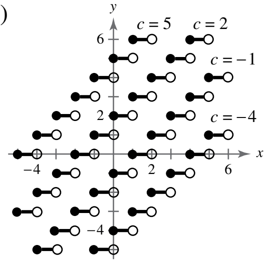
5. (a)



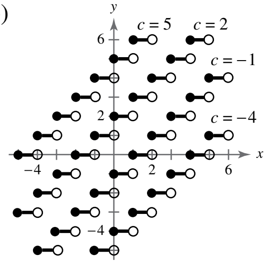
(b)



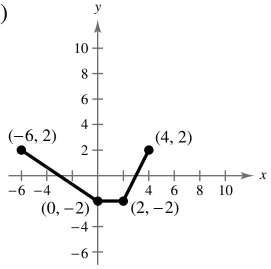
7. (a)



(b)



9. (a)



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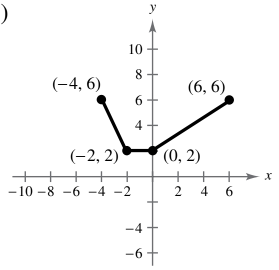
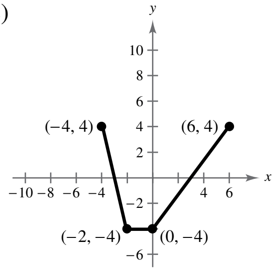
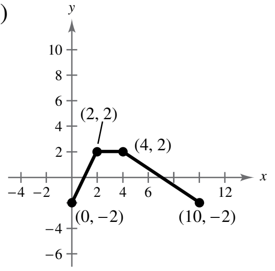


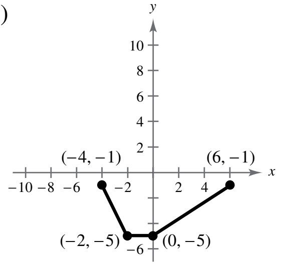
(c)



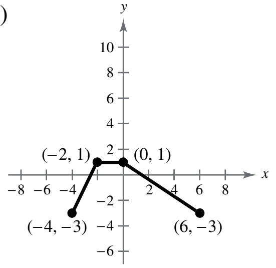
(d)



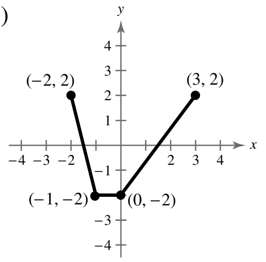
(e)



(f)



(g)



11. (a) $y = x^2 - 1$ (b) $y = -(x + 1)^2 + 1$

13. (a) $y = -|x + 3|$ (b) $y = |x - 2| - 4$

15. Right shift of $y = x^3$; $y = (x - 2)^3$

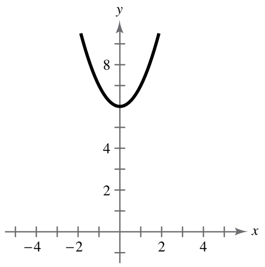
17. Reflection in the x-axis of $y = x^2$; $y = -x^2$

19. Reflection in the x-axis and upward shift of $y = \sqrt{x}$; $y = 1 - \sqrt{x}$

21. (a) $f(x) = x^2$

(b) Upward shift of six units

(c)

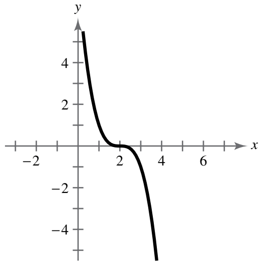


(d) $g(x) = f(x) + 6$

23. (a) $f(x) = x^3$

(b) Reflection in the x-axis and a right shift of two units

(c)

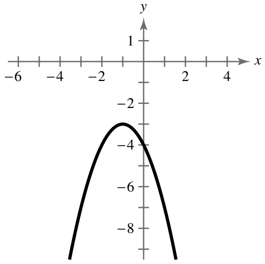


(d) $g(x) = -f(x - 2)$

25. (a) $f(x) = x^2$

(b) Reflection in the x-axis, a left shift of one unit, and a downward shift of three units

(c)

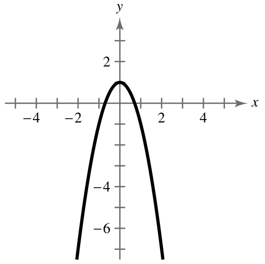


(d) $g(x) = -3 - f(x + 1)$

27. (a) $f(x) = x^2$

(b) Reflection in the x-axis, a vertical stretch, and an upward shift of one unit

(c)



(d) $g(x) = -2f(x) + 1$

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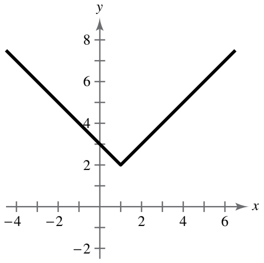
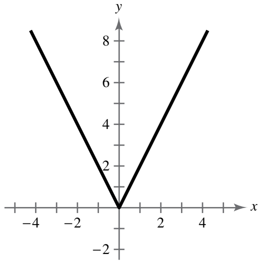
29. (a) $f(x) = |x|$
(b) Right shift of one unit and an upward shift of two units
(c)



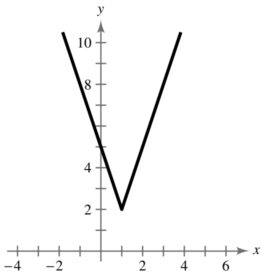
(d) $g(x) = f(x - 1) + 2$

31. (a) $f(x) = |x|$
(b) Horizontal shrink
(c)



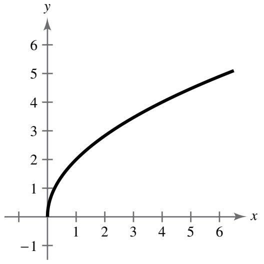
(d) $g(x) = f(2x)$

33. (a) $f(x) = |x|$
(b) Vertical stretch, a right shift of one unit, and an upward shift of two units
(c)



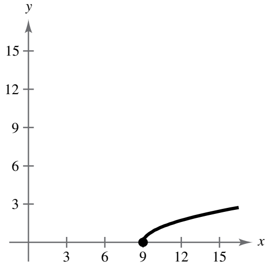
(d) $g(x) = 3f(x - 1) + 2$

35. (a) $f(x) = \sqrt{x}$ (b) Vertical stretch
(c)



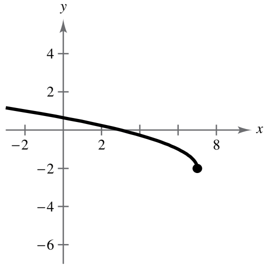
(d) $g(x) = 2f(x)$

37. (a) $f(x) = \sqrt{x}$ (b) Horizontal shift nine units to the right
(c)



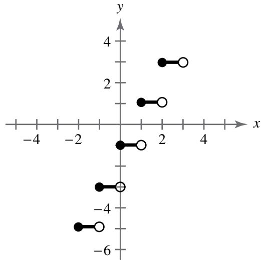
(d) $g(x) = f(x - 9)$

39. (a) $f(x) = \sqrt{x}$
(b) Reflection in the y-axis, a right shift of seven units, and a downward shift of two units
(c)



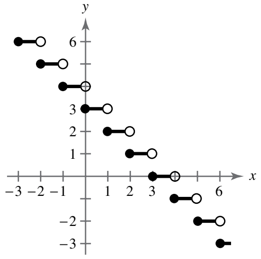
(d) $g(x) = f(7 - x) - 2$

41. (a) $f(x) = [\![x]\!]$
(b) Vertical stretch and a downward shift of one unit
(c)



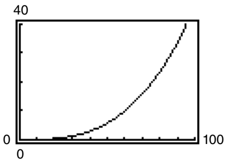
(d) $g(x) = 2f(x) - 1$

43. (a) $f(x) = [\![x]\!]$
(b) Reflection in the x-axis and an upward shift of three units
(c)



(d) $g(x) = 3 - f(x)$

45. $g(x) = (x - 3)^2 - 7$ **47.** $g(x) = (x - 13)^3$
49. $g(x) = -|x| - 12$ **51.** $g(x) = -\sqrt{-x + 6}$
53. (a) $y = -3x^2$ (b) $y = 4x^2 + 3$
55. (a) $y = -\frac{1}{2}|x|$ (b) $y = 3|x| - 3$
57. Vertical stretch of $y = x^3$; $y = 2x^3$
59. Reflection in the x-axis and vertical shrink of $y = x^2$; $y = -\frac{1}{2}x^2$
61. Reflection in the y-axis and vertical shrink of $y = \sqrt{x}$; $y = \frac{1}{2}\sqrt{-x}$
63. $y = -(x - 2)^3 + 2$ **65.** $y = -\sqrt{x} - 3$
67. (a)



(b) $H\left(\dfrac{x}{1.6}\right) = 0.00001132x^3$; Horizontal stretch

69. False. The graph of $y = f(-x)$ is a reflection of the graph of $f(x)$ in the y-axis.
71. True. $|-x| = |x|$
73. $(-2, 0)$, $(-1, 1)$, $(0, 2)$
75. The equation should be $g(x) = (x - 1)^3$.
77. No, $g(x) = -x^2 - 2$; Yes, $h(x) = -(x - 3)^2$.

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79. $x^2 + 4x$ **81.** $3x^2 + 2x - 2$ **83.** $x^3 - 3x^2$

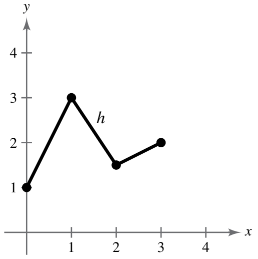
85. $-0.2x^2 - 34x$ **87.** $\frac{1}{2x}, x \neq -\frac{5}{3}$

Section 1.8 *(page 81)*

1. addition; subtraction; multiplication; division

3. $g(x) = 2x$

5.



7. (a) $2x$ (b) 4 (c) $x^2 - 4$

(d) $\frac{x+2}{x-2}$; all real numbers x except $x = 2$

9. (a) $x^2 + 4x - 5$ (b) $x^2 - 4x + 5$ (c) $4x^3 - 5x^2$

(d) $\frac{x^2}{4x-5}$; all real numbers x except $x = \frac{5}{4}$

11. (a) $x^2 + 6 + \sqrt{1-x}$ (b) $x^2 + 6 - \sqrt{1-x}$

(c) $(x^2 + 6)\sqrt{1-x}$

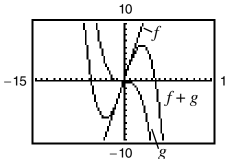
(d) $\frac{(x^2+6)\sqrt{1-x}}{1-x}$; all real numbers x such that $x < 1$

13. (a) $\frac{x^4 + x^3 + x}{x+1}$ (b) $\frac{-x^4 - x^3 + x}{x+1}$ (c) $\frac{x^4}{x+1}$

(d) $\frac{1}{x^2(x+1)}$; all real numbers x except $x = 0, -1$

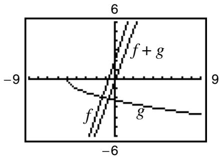
15. 7 **17.** $-9t^2 + 3t + 5$ **19.** 306 **21.** $\frac{8}{23}$

23.



$f(x), g(x)$

25.



$f(x), f(x)$

27. (a) $x + 5$ (b) $x + 5$ (c) $x - 6$

29. (a) x (b) x (c) $x^9 + 3x^6 + 3x^3 + 2$

31. (a) $\sqrt{x^2 + 4}$ (b) $x + 4$

Domains of f and $g \circ f$: all real numbers x such that $x \geq -4$

Domains of g and $f \circ g$: all real numbers x

33. (a) $|x + 6|$ (b) $|x| + 6$

Domains of $f, g, f \circ g$, and $g \circ f$: all real numbers x

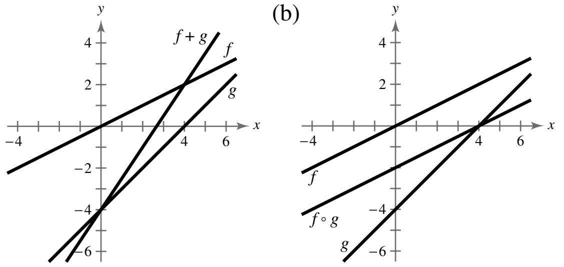
35. (a) $\frac{1}{x+3}$ (b) $\frac{1}{x} + 3$

Domains of f and $g \circ f$: all real numbers x except $x = 0$

Domain of g: all real numbers x

Domain of $f \circ g$: all real numbers x except $x = -3$

37. (a) (b)



39. (a) 3 (b) 0 **41.** (a) 0 (b) 4

43. *Sample answer:* $f(x) = x^2, g(x) = 2x + 1$

45. *Sample answer:* $f(x) = \sqrt[3]{x}, g(x) = x^2 - 4$

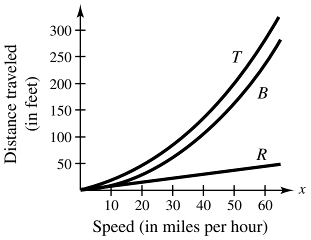
47. *Sample answer:* $f(x) = \frac{1}{x}, g(x) = x + 2$

49. *Sample answer:* $f(x) = \frac{x+3}{4+x}, g(x) = -x^2$

51. *Sample answer:* $f(x) = \sqrt{x}, g(x) = \frac{1}{x^2+1}$

53. (a) $T = \frac{3}{4}x + \frac{1}{15}x^2$

(b)



(c) The braking function $B(x)$; As x increases, $B(x)$ increases at a faster rate than $R(x)$.

55. (a) $c(t) = \frac{b(t) - d(t)}{p(t)} \times 100$

(b) $c(20)$ is the percent change in the population due to births and deaths in the year 2020.

57. (a) $r(x) = \frac{x}{2}$ (b) $A(r) = \pi r^2$

(c) $(A \circ r)(x) = \pi\left(\frac{x}{2}\right)^2$;

$(A \circ r)(x)$ represents the area of the circular base of the tank on the square foundation with side length x.

59. False. $(f \circ g)(x) = 6x + 1$ and $(g \circ f)(x) = 6x + 6$

61. (a) *Sample answer:* $f(x) = x + 1, g(x) = x + 3$

(b) *Sample answer:* $f(x) = x^2, g(x) = x^3$

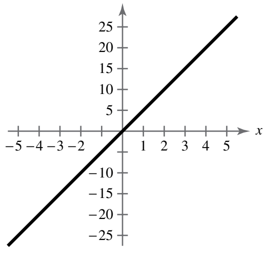
63. Proof

65. Proof

67. Symmetric with respect to x-axis

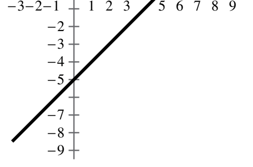
69. Symmetric with respect to y-axis

71.



Odd

73.



Neither

75. $y = \frac{5 - 2x}{3}$ **77.** $y = x^2 - 1, x \geq 0$ **79.** $4\pi(r + 1)$

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Section 1.9 *(page 90)*

1. inverse **3.** range; domain **5.** x **7.** One

9. $f^{-1}(x) = \frac{1}{6}x$ **11.** $f^{-1}(x) = \dfrac{x-1}{3}$

13. $f^{-1}(x) = \sqrt[3]{x-1}$ **15.** $f^{-1}(x) = \sqrt{x+4}$

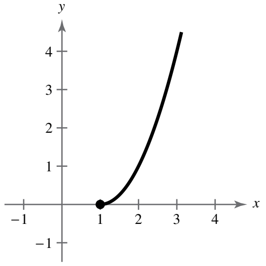
17. $f(g(x)) = f(4x+9) = \dfrac{(4x+9)-9}{4} = x$

$g(f(x)) = g\left(\dfrac{x-9}{4}\right) = 4\left(\dfrac{x-9}{4}\right) + 9 = x$

19. $f(g(x)) = f\left(\sqrt[3]{4x}\right) = \dfrac{\left(\sqrt[3]{4x}\right)^3}{4} = x$

$g(f(x)) = g\left(\dfrac{x^3}{4}\right) = \sqrt[3]{4\left(\dfrac{x^3}{4}\right)} = x$

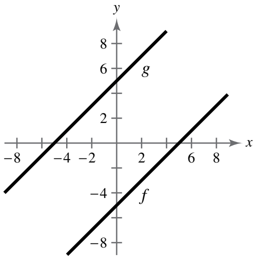
21.



23. (a) $f(g(x)) = f(x+5) = (x+5) - 5 = x$

$g(f(x)) = g(x-5) = (x-5) + 5 = x$

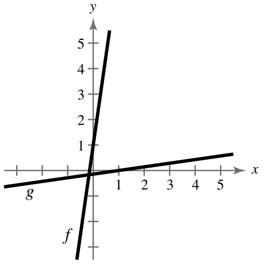
(b)



25. (a) $f(g(x)) = f\left(\dfrac{x-1}{7}\right) = 7\left(\dfrac{x-1}{7}\right) + 1 = x$

$g(f(x)) = g(7x+1) = \dfrac{(7x+1)-1}{7} = x$

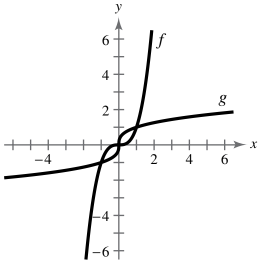
(b)



27. (a) $f(g(x)) = f\left(\sqrt[3]{x}\right) = \left(\sqrt[3]{x}\right)^3 = x$

$g(f(x)) = g(x^3) = \sqrt[3]{(x^3)} = x$

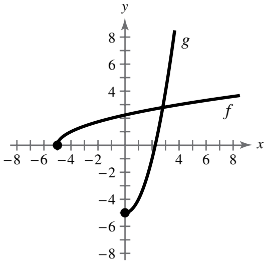
(b)



29. (a) $f(g(x)) = f(x^2-5) = \sqrt{(x^2-5)+5} = x,\ x \ge 0$

$g(f(x)) = g\left(\sqrt{x+5}\right) = \left(\sqrt{x+5}\right)^2 - 5 = x$

(b)



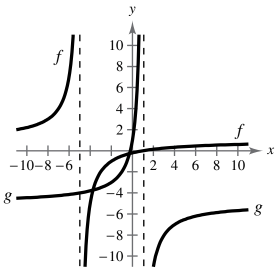
31. (a) $f(g(x)) = f\left(-\dfrac{5x+1}{x-1}\right) = \dfrac{-\left(\dfrac{5x+1}{x-1}\right) - 1}{-\left(\dfrac{5x+1}{x-1}\right) + 5}$

$= \dfrac{-5x-1-x+1}{-5x-1+5x-5} = x$

$g(f(x)) = g\left(\dfrac{x-1}{x+5}\right) = \dfrac{-5\left(\dfrac{x-1}{x+5}\right) - 1}{\dfrac{x-1}{x+5} - 1}$

$= \dfrac{-5x+5-x-5}{x-1-x-5} = x$

(b)



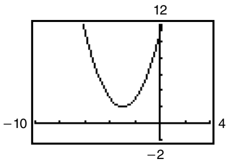
33. No

35.

x	3	5	7	9	11	13
$f^{-1}(x)$	−1	0	1	2	3	4

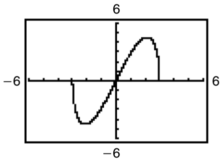
37. Yes **39.** No

41.



The function does not have an inverse function.

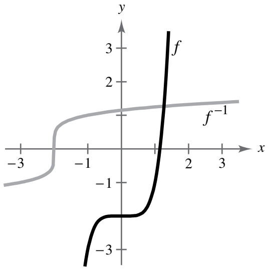
43.



The function does not have an inverse function.

45. (a) $f^{-1}(x) = \sqrt[5]{x+2}$

(b)



(c) The graph of f^{-1} is the reflection of the graph of f in the line $y = x$.

(d) The domains and ranges of f and f^{-1} are all real numbers x.

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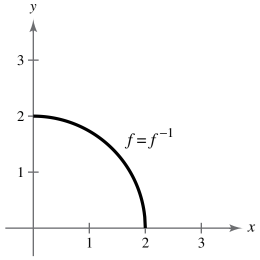
47. (a) $f^{-1}(x) = \sqrt{4 - x^2}$, $0 \le x \le 2$

(b)

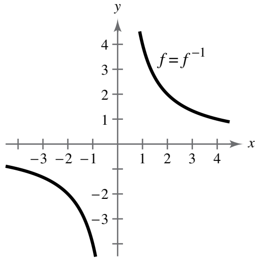


(c) The graph of f^{-1} is the same as the graph of f.

(d) The domains and ranges of f and f^{-1} are all real numbers x such that $0 \le x \le 2$.

49. (a) $f^{-1}(x) = \dfrac{4}{x}$

(b)

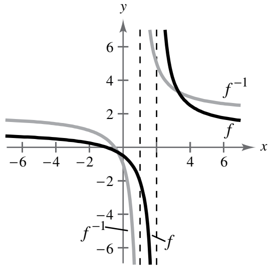


(c) The graph of f^{-1} is the same as the graph of f.

(d) The domains and ranges of f and f^{-1} are all real numbers x except $x = 0$.

51. (a) $f^{-1}(x) = \dfrac{2x + 1}{x - 1}$

(b)

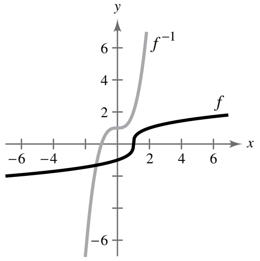


(c) The graph of f^{-1} is the reflection of the graph of f in the line $y = x$.

(d) The domain of f and the range of f^{-1} are all real numbers x except $x = 2$. The domain of f^{-1} and the range of f are all real numbers x except $x = 1$.

53. (a) $f^{-1}(x) = x^3 + 1$

(b)



(c) The graph of f^{-1} is the reflection of the graph of f in the line $y = x$.

(d) The domains and ranges of f and f^{-1} are all real numbers x.

55. No inverse function **57.** $g^{-1}(x) = 6x - 1$

59. No inverse function **61.** $f^{-1}(x) = \dfrac{x^2 - 3}{2}$, $x \ge 0$

63. $f^{-1}(x) = \dfrac{5x - 4}{6 - 4x}$ **65.** $f^{-1}(x) = \sqrt{x} - 3$

67. No inverse function

69. (a) $y = \dfrac{x - 10}{0.75}$

x = hourly wage; y = number of units produced

(b) 19 units

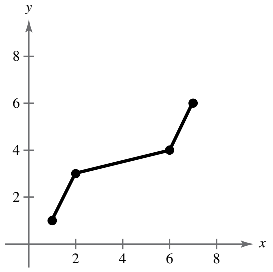
71. $\dfrac{x + 1}{2}$ **73.** $\dfrac{x + 1}{2}$ **75.** 32 **77.** 472

79. $2\sqrt[3]{x + 3}$ **81.** False. $f(x) = x^2$ has no inverse function.

83. (a)

x	1	3	4	6
y	1	2	6	7

x	1	2	6	7
$f^{-1}(x)$	1	3	4	6



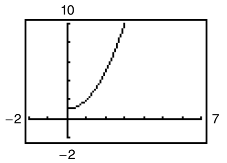
(b)

x	−4	−2	0	3
y	3	4	0	−1

The graph of f does not pass the Horizontal Line Test, so $f^{-1}(x)$ does not exist.

85. Proof

87.



There is an inverse function $f^{-1}(x) = \sqrt{x - 1}$ because the domain of f is equal to the range of f^{-1} and the range of f is equal to the domain of f^{-1}.

89. $y = -(x - 6)(x - 4)$ **91.** $y = -(x - 9)(x - 4)$

93. Increasing on $(2, \infty)$
Decreasing on $(-\infty, 2)$

95. Increasing on $(-\infty, -1)$, $(1, \infty)$
Decreasing on $(-1, 1)$

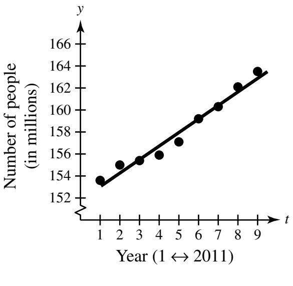
97. Relative minimum: $(0, -3)$
Relative maximum: $(2, 0)$

Section 1.10 *(page 100)*

1. sum; squared differences **3.** correlation coefficient

5. z varies jointly as x and y; z is jointly proportional to x and y.

7. (a)



(b) The model is a good fit for the data.

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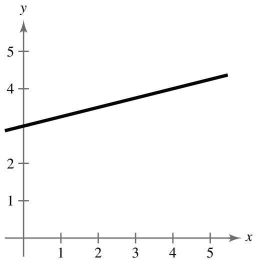
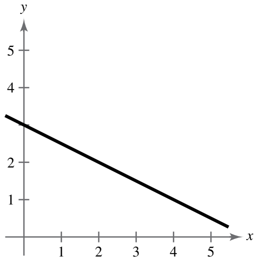
9.



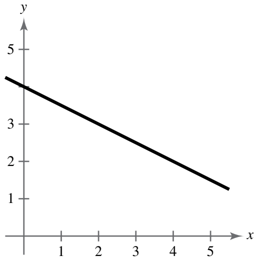
$y = \frac{1}{4}x + 3$

11.



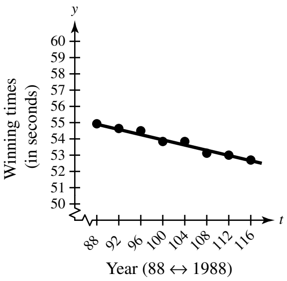
$y = -\frac{1}{2}x + 3$

13.



$y = -\frac{1}{2}x + 4$

15. (a) and (b)



Sample answer: $y = -0.080t + 61.94$

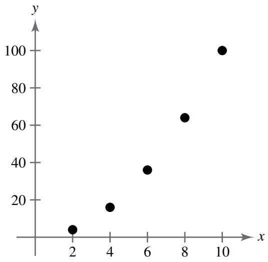
(c) $y = -0.083t + 62.30$

(d) The models are similar.

17. $y = 7x$ **19.** $y = -\frac{1}{8}x$ **21.** $y = 2\pi x$

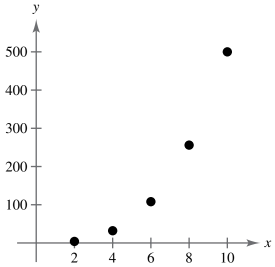
23.

x	2	4	6	8	10
$y = x^2$	4	16	36	64	100



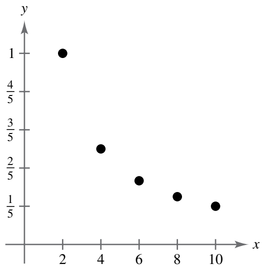
25.

x	2	4	6	8	10
$y = \frac{1}{2}x^3$	4	32	108	256	500



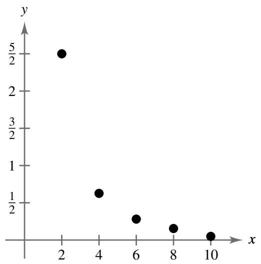
27.

x	2	4	6	8	10
$y = \dfrac{2}{x}$	1	$\frac{1}{2}$	$\frac{1}{3}$	$\frac{1}{4}$	$\frac{1}{5}$



29.

x	2	4	6	8	10
$y = \dfrac{10}{x^2}$	$\frac{5}{2}$	$\frac{5}{8}$	$\frac{5}{18}$	$\frac{5}{32}$	$\frac{1}{10}$



31. $y = \dfrac{5}{x}$ **33.** $y = -\dfrac{7}{10}x$ **35.** $A = kr^2$

37. $y = \dfrac{k}{x^2}$ **39.** $F = \dfrac{kg}{r^2}$ **41.** $R = k(T - T_e)$

43. $P = kVI$ **45.** y is directly proportional to the square of x.

47. A is jointly proportional to b and h.

49. $y = 18x$ **51.** $y = \dfrac{75}{x}$ **53.** $z = 2xy$

55. $P = \dfrac{18x}{y^2}$ **57.** $I = 0.035P$

59. Model: $y = \frac{33}{13}x$; 25.4 cm, 50.8 cm

61. $293\frac{1}{3}$ N

63. About 39.47 lb

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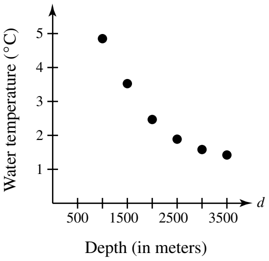
65. (a)



(b) Inverse variation

(c) About 4919.9

(d) 1640 m

67. About 0.61 mi/h

69. (a) 200 Hz (b) 50 Hz (c) 100 Hz

71. True. If $y = k_1x$ and $x = k_2z$, then $y = k_1(k_2z) = (k_1k_2)z$.

73. False. π is not a variable.

75. True. $f(2) = (2 - 2)p(2) = 0$

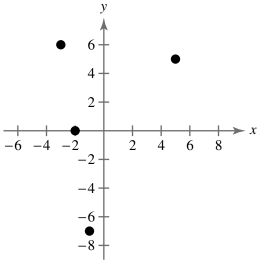
77. $\dfrac{-x - 1}{5x - 4}$ **79.** $\dfrac{2x^2 + 3x + 15}{(x - 1)(x + 3)}$

81. $\dfrac{4}{3(2x + 1)}, x \neq -3$ **83.** Yes; All real numbers x

85. No **87.** Yes; All real numbers x such that $x \geq -5$

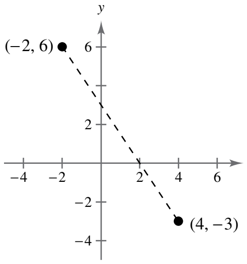
Review Exercises *(page 106)*

1.



3. Quadrant IV

5.

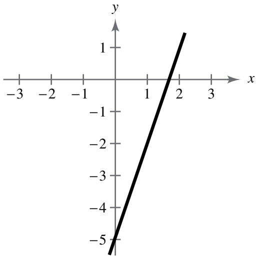


Distance: $3\sqrt{13}$

Midpoint: $\left(1, \frac{3}{2}\right)$

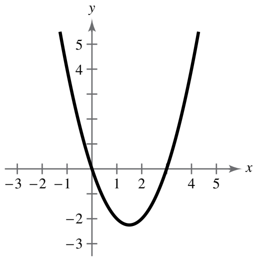
7.

x	-2	-1	0	1	2
y	-11	-8	-5	-2	1



9.

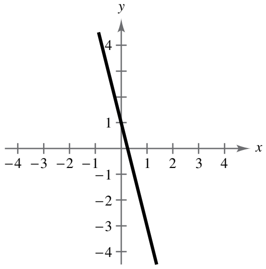
x	-1	0	1	2	3	4
y	4	0	-2	-2	0	4



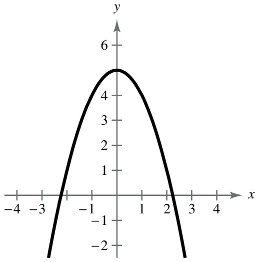
11. x-intercept: $\left(-\frac{7}{2}, 0\right)$
y-intercept: $(0, 7)$

13. x-intercepts: $(1, 0), (5, 0)$
y-intercept: $(0, 5)$

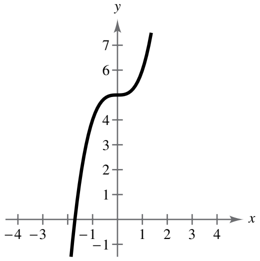
15. x-intercept: $\left(\frac{1}{4}, 0\right)$
y-intercept: $(0, 1)$
No symmetry



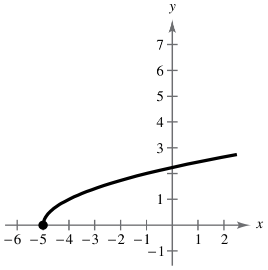
17. x-intercepts: $\left(\pm\sqrt{6}, 0\right)$
y-intercept: $(0, 6)$
y-axis symmetry



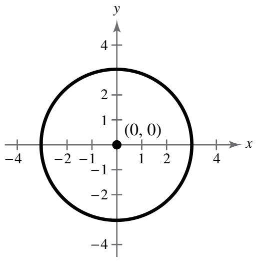
19. x-intercept: $\left(\sqrt[3]{-5}, 0\right)$
y-intercept: $(0, 5)$
No symmetry



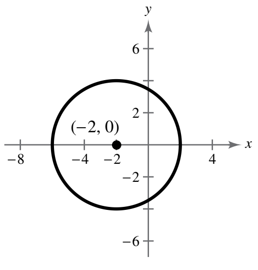
21. x-intercept: $(-5, 0)$
y-intercept: $\left(0, \sqrt{5}\right)$
No symmetry



23. Center: $(0, 0)$
Radius: 3



25. Center: $(-2, 0)$
Radius: 4



27. $(x - 2)^2 + (y + 3)^2 = 13$

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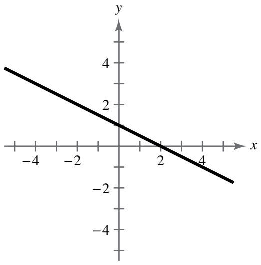
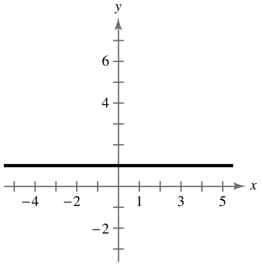
29. $m = -\frac{1}{2}$
y-intercept: $(0, 1)$

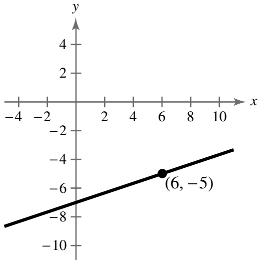


31. $m = 0$
y-intercept: $(0, 1)$

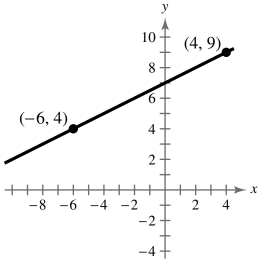


33. $m = -1$

35. $y = \frac{1}{3}x - 7$



37. $y = \frac{1}{2}x + 7$



39. (a) $y = \frac{5}{4}x - \frac{23}{4}$ (b) $y = -\frac{4}{5}x + \frac{2}{5}$

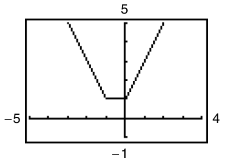
41. $S = 0.80L$ **43.** Not a function **45.** Function

47. (a) 5 (b) 17 (c) $t^4 + 1$ (d) $t^2 + 2t + 2$

49. All real numbers x such that $-5 \le x \le 5$ **51.** 16 ft/sec

53. $4x + 2h + 3, \quad h \ne 0$ **55.** Function **57.** $\frac{7}{3}$, 3

59.

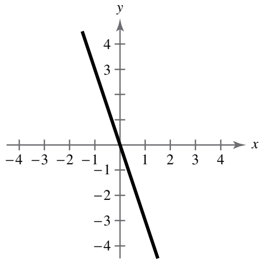


Increasing on $(0, \infty)$
Decreasing on $(-\infty, -1)$
Constant on $(-1, 0)$

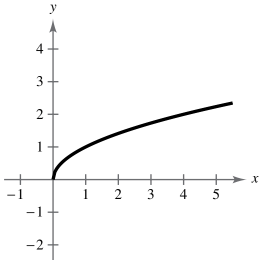
61. Relative maximum: $(1, 2)$ **63.** 4

65. Even; y-axis symmetry

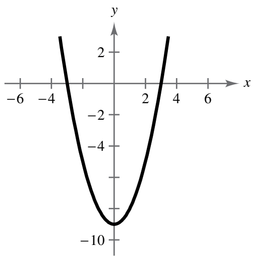
67. (a) $f(x) = -3x$
(b)



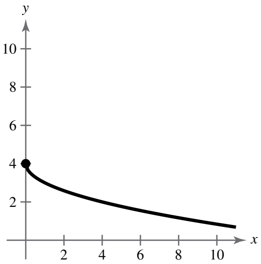
69.



71. (a) $f(x) = x^2$ (b) Downward shift of nine units
(c) (d) $h(x) = f(x) - 9$

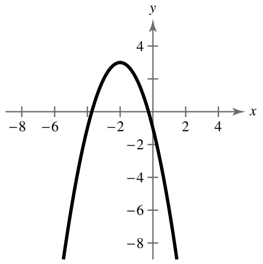


73. (a) $f(x) = \sqrt{x}$
(b) Reflection in the x-axis and an upward shift of four units
(c)



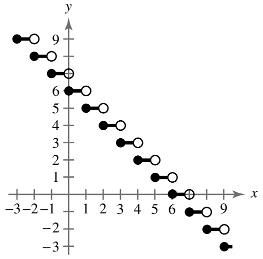
(d) $h(x) = -f(x) + 4$

75. (a) $f(x) = x^2$
(b) Reflection in the x-axis, a left shift of two units, and an upward shift of three units
(c)



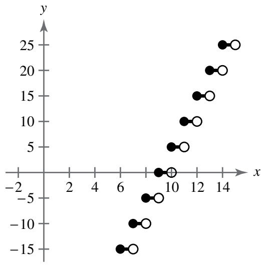
(d) $h(x) = -f(x + 2) + 3$

77. (a) $f(x) = [\![x]\!]$
(b) Reflection in the x-axis and an upward shift of six units
(c)



(d) $h(x) = -f(x) + 6$

79. (a) $f(x) = [\![x]\!]$
(b) Right shift of nine units and a vertical stretch
(c)



(d) $h(x) = 5f(x - 9)$

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81. (a) $x^2 + 2x + 2$ (b) $x^2 - 2x + 4$
(c) $2x^3 - x^2 + 6x - 3$
(d) $\dfrac{x^2 + 3}{2x - 1}$; all real numbers x except $x = \dfrac{1}{2}$

83. (a) $x - \frac{8}{3}$ (b) $x - 8$
Domains of f, g, $f \circ g$, and $g \circ f$: all real numbers x

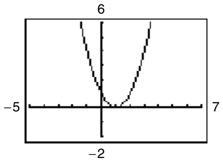
85. $f(g(x)) = 0.95x - 100$; $(f \circ g)(x)$ represents the 5% discount before the \$100 rebate.

87. $f^{-1}(x) = \dfrac{x - 8}{3}$

$$f(f^{-1}(x)) = 3\left(\frac{x - 8}{3}\right) + 8 = x$$

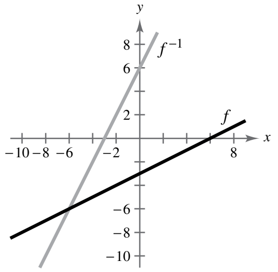
$$f^{-1}(f(x)) = \frac{3x + 8 - 8}{3} = x$$

89.



Not one-to-one

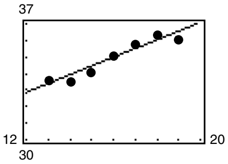
91. (a) $f^{-1}(x) = 2x + 6$
(b)



(c) The graphs are reflections of each other in the line $y = x$.
(d) Both f and f^{-1} have domains and ranges that are all real numbers x.

93. $x > 4$; $f^{-1}(x) = \sqrt{\dfrac{x}{2}} + 4,\ x \neq 0$

95. (a) and (b)



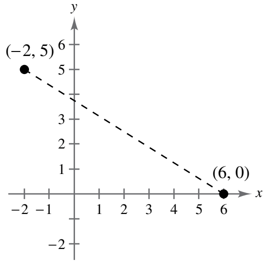
$C = 0.53t + 26.5$
The model fits the data well.

97. 909 pastries

99. True. If $f(x) = x^3$ and $g(x) = \sqrt[3]{x}$, then the domain of g is all real numbers x, which is equal to the range of f, and vice versa.

Chapter Test *(page 109)*

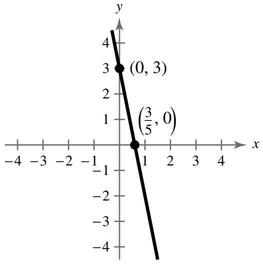
1.



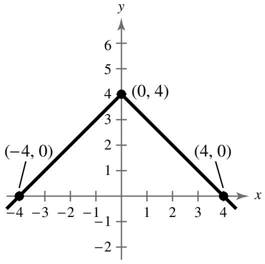
Midpoint: $\left(2, \frac{5}{2}\right)$; Distance: $\sqrt{89}$

2. $V(h) = 16\pi h$

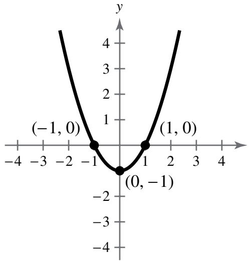
3. x-intercept: $\left(\frac{3}{5}, 0\right)$
y-intercept: $(0, 3)$
No symmetry



4. x-intercepts: $(\pm 4, 0)$
y-intercept: $(0, 4)$
y-axis symmetry

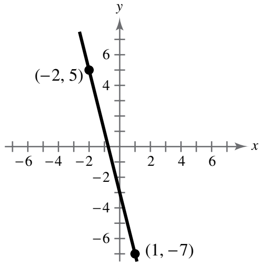


5. x-intercepts: $(\pm 1, 0)$
y-intercept: $(0, -1)$
y-axis symmetry

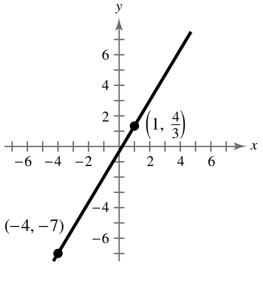


6. $(x - 1)^2 + (y - 3)^2 = 16$

7. $y = -4x - 3$



8. $y = \frac{5}{3}x - \frac{1}{3}$



9. (a) $y = -\frac{5}{2}x + 4$ (b) $y = \frac{2}{5}x + 4$

10. (a) $-\dfrac{1}{8}$ (b) $-\dfrac{1}{28}$ (c) $\dfrac{\sqrt{x}}{x^2 - 18x}$

11. $x \leq 3$

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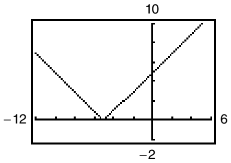
12. (a) -5

(b)

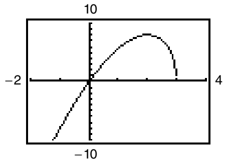


(c) Increasing on $(-5, \infty)$
Decreasing on $(-\infty, -5)$

(d) Neither

13. (a) 0, 3

(b)

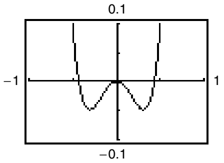


(c) Increasing on $(-\infty, 2)$
Decreasing on $(2, 3)$

(d) Neither

14. (a) $0, \pm 0.4314$

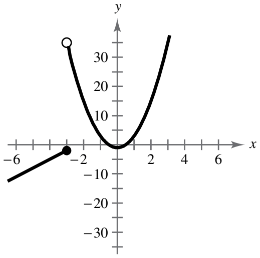
(b)



(c) Increasing on $(-0.31, 0)$, $(0.31, \infty)$
Decreasing on $(-\infty, -0.31)$, $(0, 0.31)$

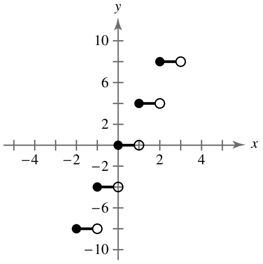
(d) Even

15.



16. (a) $f(x) = [\![x]\!]$ (b) Vertical stretch

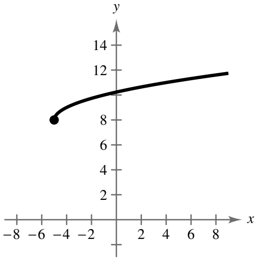
(c)



17. (a) $y = \sqrt{x}$

(b) Left shift of five units and an upward shift of eight units

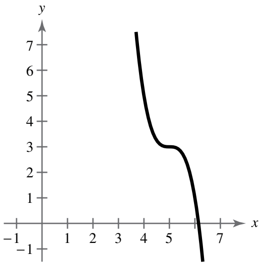
(c)



18. (a) $y = x^3$

(b) Reflection in the x-axis, a vertical stretch, a right shift of five units, and an upward shift of three units

(c)



19. (a) $2x^2 - 4x - 2$ (b) $4x^2 + 4x - 12$

(c) $-3x^4 - 12x^3 + 22x^2 + 28x - 35$

(d) $\dfrac{3x^2 - 7}{-x^2 - 4x + 5}$

(e) $3x^4 + 24x^3 + 18x^2 - 120x + 68$

(f) $-9x^4 + 30x^2 - 16$

20. (a) $\dfrac{1 + 2x^{3/2}}{x}$ (b) $\dfrac{1 - 2x^{3/2}}{x}$

(c) $\dfrac{2\sqrt{x}}{x}$ (d) $\dfrac{1}{2x^{3/2}}$

(e) $\dfrac{\sqrt{x}}{2x}$ (f) $\dfrac{2\sqrt{x}}{x}$

21. $f^{-1}(x) = \sqrt[3]{x - 8}$ **22.** No inverse

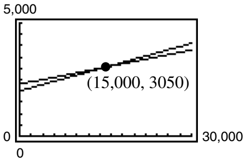
23. $f^{-1}(x) = \left(\frac{1}{3}x\right)^{2/3},\quad x \geq 0$ **24.** $v = 6\sqrt{s}$

25. $A = \dfrac{25}{6}xy$ **26.** $b = \dfrac{48}{a}$

Problem Solving *(page 111)*

1. (a) $W_1 = 2000 + 0.07S$ (b) $W_2 = 2300 + 0.05S$

(c)



Both jobs pay the same monthly salary when sales equal \$15,000.

(d) No. Job 1 would pay \$3400 and job 2 would pay \$3300.

3. (a) The function will be even.

(b) The function will be odd.

(c) The function will be neither even nor odd.

5. $f(x) = a_{2n}x^{2n} + a_{2n-2}x^{2n-2} + \cdot \cdot \cdot + a_2x^2 + a_0$

$f(-x) = a_{2n}(-x)^{2n} + a_{2n-2}(-x)^{2n-2} + \cdot \cdot \cdot + a_2(-x)^2 + a_0$

$= f(x)$

7. (a) $81\frac{2}{3}$ h

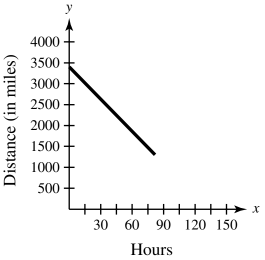
(b) $25\frac{5}{7}$ mi/h

(c) $y = \dfrac{-180}{7}x + 3400$

Domain: $0 \leq x \leq \dfrac{245}{3}$

Range: $1300 \leq y \leq 3400$

(d)



9. (a) $(f \circ g)(x) = 4x + 24$ (b) $(f \circ g)^{-1}(x) = \frac{1}{4}x - 6$

(c) $f^{-1}(x) = \frac{1}{4}x;\ g^{-1}(x) = x - 6$

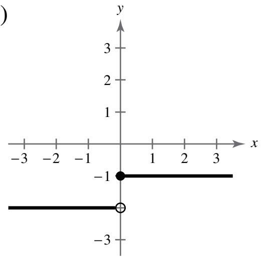
(d) $(g^{-1} \circ f^{-1})(x) = \frac{1}{4}x - 6$; They are the same.

(e) $(f \circ g)(x) = 8x^3 + 1;\ (f \circ g)^{-1}(x) = \frac{1}{2}\sqrt[3]{x - 1};$
$f^{-1}(x) = \sqrt[3]{x - 1};\ g^{-1}(x) = \frac{1}{2}x;$
$(g^{-1} \circ f^{-1})(x) = \frac{1}{2}\sqrt[3]{x - 1}$

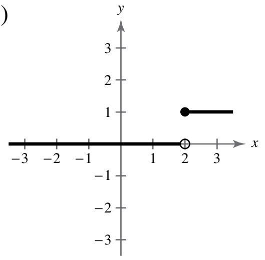
(f) Answers will vary.

(g) $(f \circ g)^{-1}(x) = (g^{-1} \circ f^{-1})(x)$

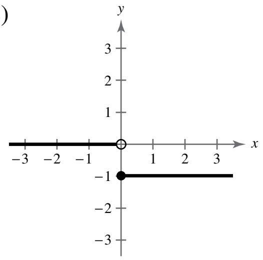
11. (a)



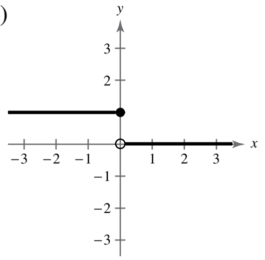
(b)



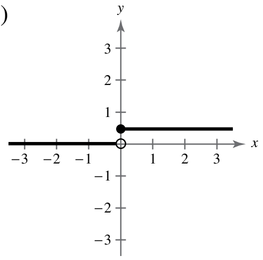
(c)



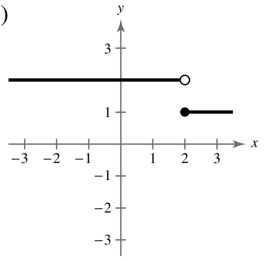
(d)



(e)



(f)



13. Proof

15. (a)

x	-4	-2	0	4
$f(f^{-1}(x))$	-4	-2	0	4

(b)

x	-3	-2	0	1
$(f + f^{-1})(x)$	5	1	-3	-5

(c)

x	-3	-2	0	1
$(f \cdot f^{-1})(x)$	4	0	2	6

(d)

x	-4	-3	0	4
$\lvert f^{-1}(x)\rvert$	2	1	1	3

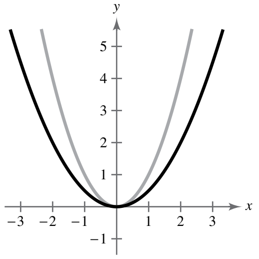
Chapter 2

Section 2.1 *(page 120)*

1. nonnegative integer; real **3.** Yes; $\left(\frac{1}{2}, 3\right)$

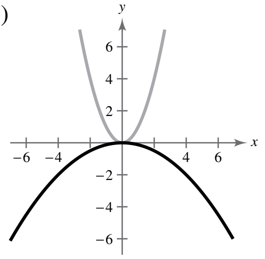
5. b **6.** a **7.** c **8.** d

9. (a)



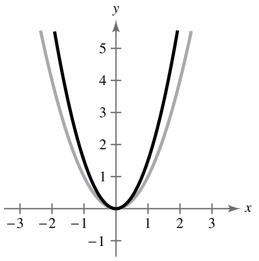
Vertical shrink

(b)



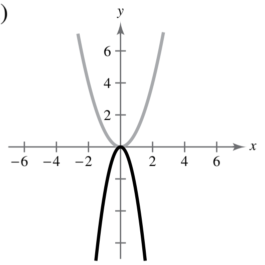
Vertical shrink and a reflection in the *x*-axis

(c)



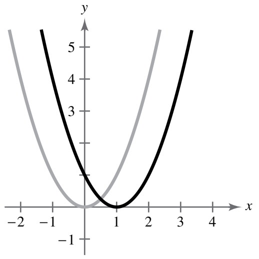
Vertical stretch

(d)



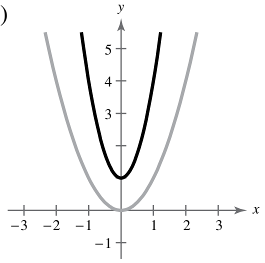
Vertical stretch and a reflection in the *x*-axis

11. (a)



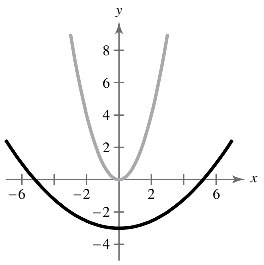
Right shift of one unit

(b)



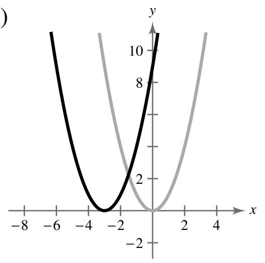
Horizontal shrink and an upward shift of one unit

(c)



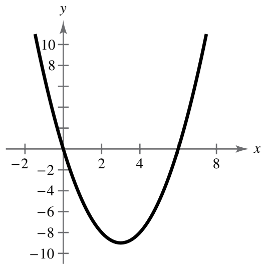
Horizontal stretch and a downward shift of three units

(d)



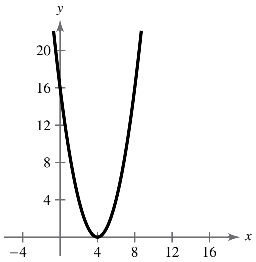
Left shift of three units

13. $f(x) = (x - 3)^2 - 9$



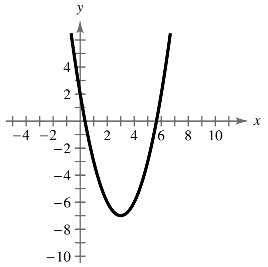
Vertex: $(3, -9)$
Axis of symmetry: $x = 3$
x-intercepts: $(0, 0), (6, 0)$

15. $h(x) = (x - 4)^2$



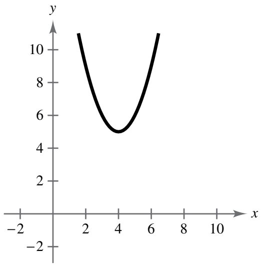
Vertex: $(4, 0)$
Axis of symmetry: $x = 4$
x-intercept: $(4, 0)$

17. $f(x) = (x - 3)^2 - 7$



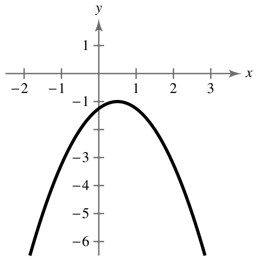
Vertex: $(3, -7)$
Axis of symmetry: $x = 3$
x-intercepts: $\left(3 \pm \sqrt{7}, 0\right)$

19. $f(x) = (x + 6)^2 + 4$



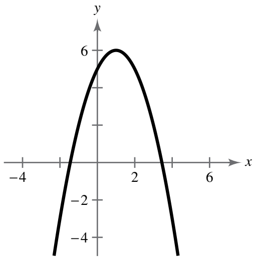
Vertex: $(-6, 4)$
Axis of symmetry: $x = -6$
No x-intercept

21. $f(x) = -\left(x - \frac{1}{2}\right)^2 - 1$



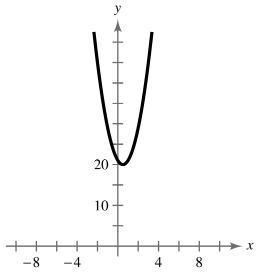
Vertex: $\left(\frac{1}{2}, -1\right)$
Axis of symmetry: $x = \frac{1}{2}$
No x-intercept

23. $f(x) = -(x - 1)^2 + 6$



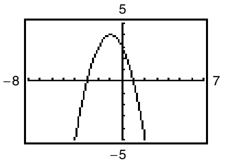
Vertex: $(1, 6)$
Axis of symmetry: $x = 1$
x-intercepts: $\left(1 \pm \sqrt{6}, 0\right)$

25. $h(x) = 4\left(x - \frac{1}{2}\right)^2 + 20$



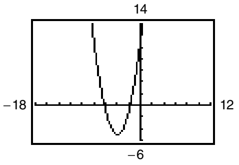
Vertex: $\left(\frac{1}{2}, 20\right)$
Axis of symmetry: $x = \frac{1}{2}$
No x-intercept

27.



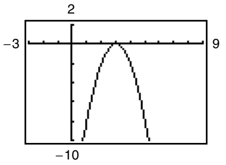
Vertex: $(-1, 4)$
Axis of symmetry: $x = -1$
x-intercepts: $(1, 0), (-3, 0)$

29.



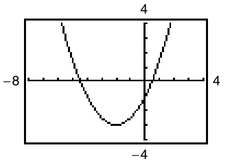
Vertex: $(-4, -5)$
Axis of symmetry: $x = -4$
x-intercepts: $\left(-4 \pm \sqrt{5}, 0\right)$

31.



Vertex: $(3, 0)$
Axis of symmetry: $x = 3$
x-intercept: $(3, 0)$

33.



Vertex: $(-2, -3)$
Axis of symmetry: $x = -2$
x-intercepts: $\left(-2 \pm \sqrt{6}, 0\right)$

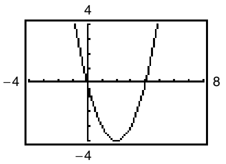
35. $f(x) = (x + 2)^2 - 1$ **37.** $f(x) = (x + 2)^2 + 5$

39. $f(x) = 4(x - 1)^2 - 2$ **41.** $f(x) = \frac{3}{4}(x - 5)^2 + 12$

43. $f(x) = -\frac{24}{49}\left(x + \frac{1}{4}\right)^2 + \frac{3}{2}$ **45.** $(-1, 0), (3, 0)$

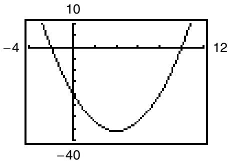
47. $(-3, 0), \left(\frac{1}{2}, 0\right)$

49.



$(0, 0), (4, 0)$

51.



$(-2, 0), (10, 0)$

53. (a) $f(x) = x^2 - 9$
(b) $g(x) = -x^2 + 9$

55. (a) $f(x) = x^2 - 2x + 1$
(b) $g(x) = -x^2 + 1$

57. 55, 55 **59.** 12, 6 **61.** 16 ft **63.** 20 fixtures

65. (a) $A = \dfrac{8x(50 - x)}{3}$
(b) $x = 25$ ft, $y = 33\frac{1}{3}$ ft

67. True. The equation has no real solutions, so the graph has no x-intercepts.

69. $b = \pm 10$ **71.** $f(x) = a\left(x + \dfrac{b}{2a}\right)^2 + \dfrac{4ac - b^2}{4a}$

73. (a) $3x^4$ (b) Degree: 4; Leading coefficient: 3
(c) Monomial

75. (a) $-4x^2 + x + 1$ (b) Degree: 2; Leading coefficient: -4
(c) Trinomial

77. (a) $-29x^3 + \frac{1}{4}x$ (b) Degree: 3; Leading coefficient: -29
(c) Binomial

79. $y^2 - 10y + 9$ **81.** $x^4 - 3x^3 - 9x^2 + 10x + 6$

83. x-intercept: $(-2, 0)$; y-intercept: $(0, 4)$

85. x-intercepts: $(2, 0), (6, 0)$; y-intercept: $(0, 2)$

Section 2.2 *(page 132)*

1. continuous **3.** touches; crosses **5.** No
7. $f(x_2) > 0$

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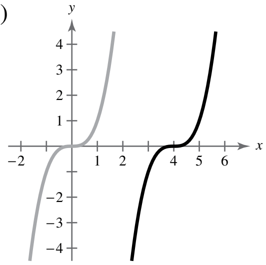
9. (a)



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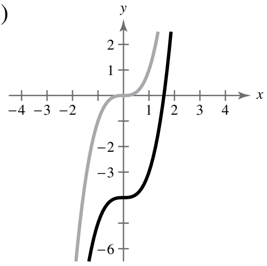

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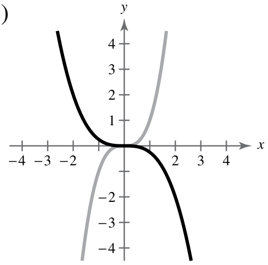

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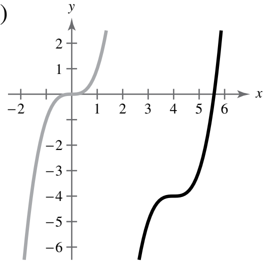
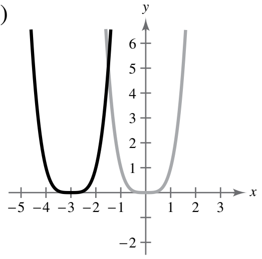
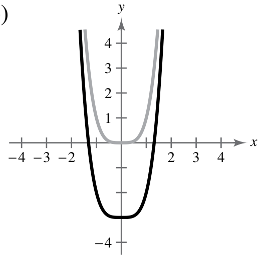


11. (a)



(b)



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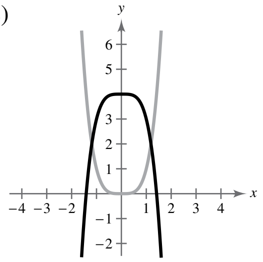
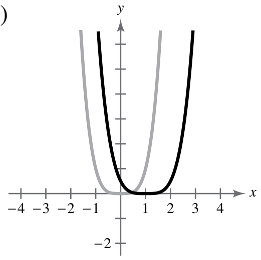
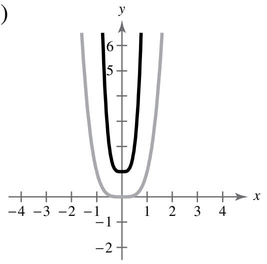


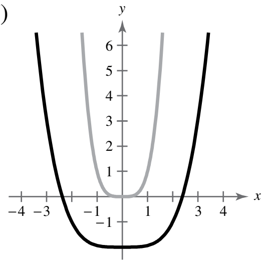
(d)



(e)



(f)



13. c **14.** f **15.** a **16.** e **17.** d **18.** b

19. Falls to the left, rises to the right

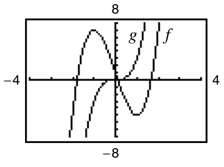
21. Falls to the left and to the right

23. Rises to the left, falls to the right

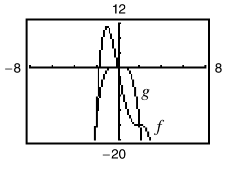
25. Rises to the left and to the right

27. Rises to the left, falls to the right

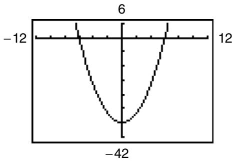
29.



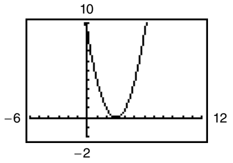
31.



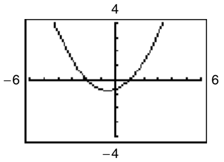
33. (a) ±6
(b) Odd multiplicity
(c) 1
(d)



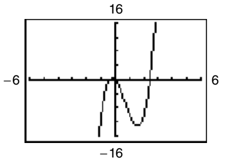
35. (a) 3
(b) Even multiplicity
(c) 1
(d)



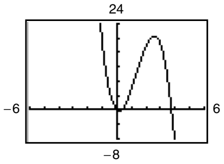
37. (a) −2, 1
(b) Odd multiplicity
(c) 1
(d)



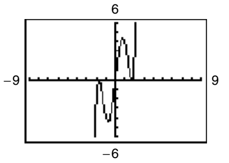
39. (a) 0, $1 \pm \sqrt{2}$
(b) Odd multiplicity
(c) 2
(d)



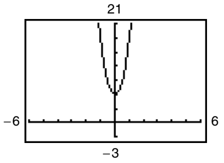
41. (a) 0, $2 \pm \sqrt{3}$
(b) Odd multiplicity
(c) 2
(d)



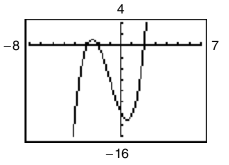
43. (a) 0, $\pm\sqrt{3}$
(b) 0, odd multiplicity;
$\pm\sqrt{3}$, even multiplicity
(c) 4
(d)



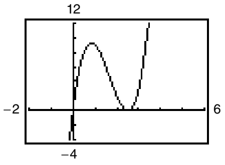
45. (a) No real zero
(b) No multiplicity
(c) 1
(d)



47. (a) ±2, −3
(b) Odd multiplicity
(c) 2
(d)

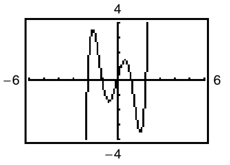


49. (a)



(b) and (c) 0, $\frac{5}{2}$
(d) The answers are the same.

51. (a)



(b) and (c) 0, ±1, ±2
(d) The answers are the same.

53. $f(x) = x^2 - 7x$

55. $f(x) = x^3 + 6x^2 + 8x$

57. $f(x) = x^4 - 4x^3 - 9x^2 + 36x$

59. $f(x) = x^2 - 2x - 1$

61. $f(x) = x^3 - 6x^2 + 7x + 2$

63. $f(x) = x^2 + 6x + 9$

65. $f(x) = x^3 + 4x^2 - 5x$

67. $f(x) = x^4 + x^3 - 15x^2 + 23x - 10$

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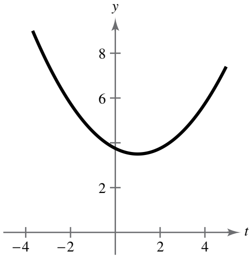
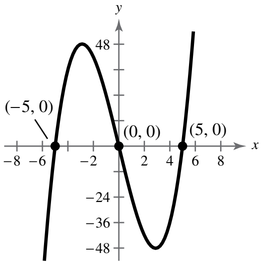
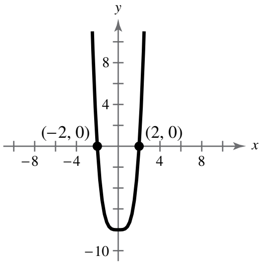
69. (a) Rises to the left and to the right
(b) No zeros (c) Answers will vary.
(d)



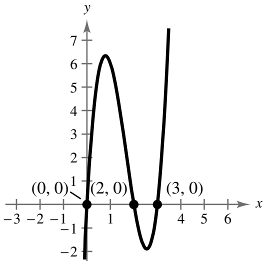
71. (a) Falls to the left, rises to the right
(b) 0, 5, −5 (c) Answers will vary.
(d)



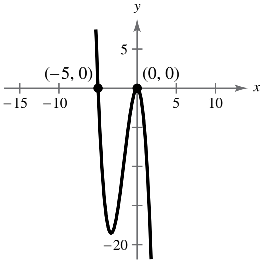
73. (a) Rises to the left and to the right
(b) −2, 2 (c) Answers will vary.
(d)



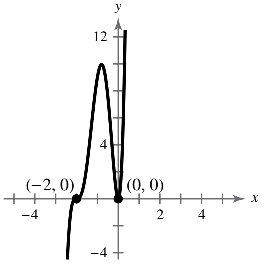
75. (a) Falls to the left, rises to the right
(b) 0, 2, 3 (c) Answers will vary.
(d)



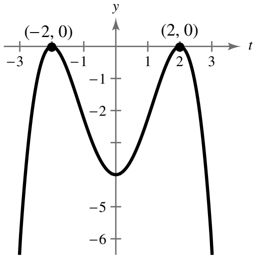
77. (a) Rises to the left, falls to the right
(b) −5, 0 (c) Answers will vary.
(d)



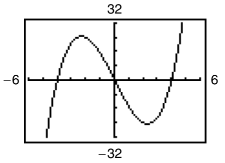
79. (a) Falls to the left, rises to the right
(b) −2, 0 (c) Answers will vary.
(d)



81. (a) Falls to the left and to the right
(b) ±2 (c) Answers will vary.
(d)

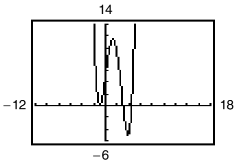


83.



Zeros: 0, ±4,
odd multiplicity

85.

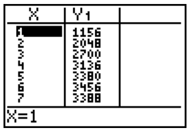


Zeros: −1,
even multiplicity;
3, $\frac{9}{2}$, odd multiplicity

87. (a) [−1, 0], [1, 2], [2, 3]
(b) −0.879, 1.347, 2.532

89. (a) [−2, −1], [0, 1]
(b) −1.585, 0.779

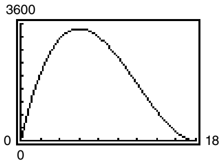
91. (a) $V(x) = x(36 - 2x)^2$
(b) Domain: $0 < x < 18$
(c)



```
X    Y1
1    1156
2    2048
3    2700
4    3136
5    3380
6    3456
7    3388
X=1
```

6 in. × 24 in. × 24 in.

(d)



$x = 6$; The results are the same.

93. $x \approx 200$

95. False. The graph will always cross the x-axis.

97. True. A polynomial function falls to the right only when the leading coefficient is negative.

99. False. The graph falls to the left and to the right or the graph rises to the left and to the right.

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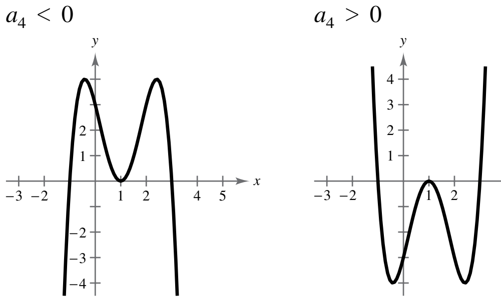
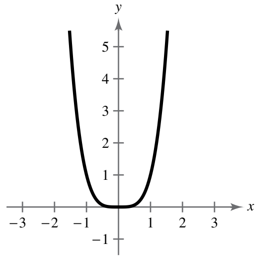
101. Answers will vary. *Sample answers:*


$a_4 < 0$ $\quad$ $a_4 > 0$

The x-intercepts of the graphs are the same. The first graph falls to the left and to the right. The second graph rises to the left and to the right. The second graph is a reflection of the first graph in the x-axis.

103.

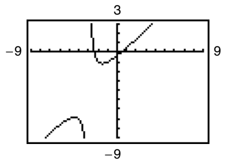


(a) Upward shift of two units; Even
(b) Left shift of two units; Neither
(c) Reflection in the y-axis; Even
(d) Reflection in the x-axis; Even
(e) Horizontal stretch; Even (f) Vertical shrink; Even
(g) $g(x) = x^3, x \geq 0$; Neither (h) $g(x) = x^{16}$; Even

105. 27 **107.** $56\frac{7}{10}$ **109.** $28\frac{108}{151}$ **111.** $3n^2 + 3n - 1$
113. $5x^2 + 7x + 4$ **115.** $-2 + 5i$ **117.** $21 - 52i$
119. $\frac{1}{10} - \frac{7}{10}i$ **121.** $-\frac{1}{2} - \frac{5}{2}i$

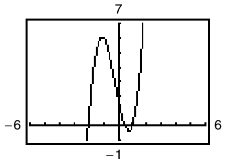
Section 2.3 *(page 142)*

1. $f(x)$: dividend; $d(x)$: divisor;
$q(x)$: quotient; $r(x)$: remainder
3. proper **5.** synthetic division **7.** Answers will vary.
9. (a) and (b)

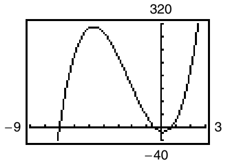


(c) Answers will vary.

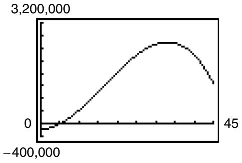
11. $6 - \dfrac{1}{x+1}$ **13.** $2x + 4,\ x \neq -3$
15. $x^3 + 3x^2 - 1,\ x \neq -2$ **17.** $x - \dfrac{x+9}{x^2+1}$
19. $2x - 8 + \dfrac{x-1}{x^2+1}$ **21.** $2x^2 - 2x + 6,\ x \neq 4$
23. $6x^2 + 25x + 74 + \dfrac{248}{x-3}$ **25.** $4x^2 - 9,\ x \neq -2$
27. $-x^2 + 10x - 25,\ x \neq -10$ **29.** $x^2 + x + 4 + \dfrac{21}{x-4}$
31. $10x^3 + 10x^2 + 60x + 360 + \dfrac{1360}{x-6}$
33. $x^2 - 8x + 64,\ x \neq -8$ **35.** $4x^2 + 14x - 30,\ x \neq -\frac{1}{2}$
37. $f(x) = (x-3)(x^2 + 2x - 4) - 5,\ f(3) = -5$
39. $f(x) = \left(x + \frac{2}{3}\right)(15x^3 - 6x + 4) + \frac{34}{3},\ f\left(-\frac{2}{3}\right) = \frac{34}{3}$
41. (a) -2 (b) 1 (c) 36 (d) 5
43. (a) 15 (b) 240 (c) 695 (d) 56,720
45. $(x+3)(x+2)(x+1)$; Solutions: $-3, -2, -1$
47. $(2x-1)(x-5)(x-2)$; Solutions: $\frac{1}{2}, 5, 2$
49. $\left(x + \sqrt{3}\right)\left(x - \sqrt{3}\right)(x+2)$; Solutions: $-\sqrt{3}, \sqrt{3}, -2$
51. (a) Answers will vary. (b) $2x - 1$
(c) $f(x) = (2x-1)(x+2)(x-1)$ (d) $\frac{1}{2}, -2, 1$
(e)



53. (a) Answers will vary. (b) $x + 7$
(c) $f(x) = (x+7)(2x+1)(3x-2)$ (d) $-7, -\frac{1}{2}, \frac{2}{3}$
(e)



55. (a) $2, \pm 2.236$ (b) 2
(c) $f(x) = (x-2)\left(x - \sqrt{5}\right)\left(x + \sqrt{5}\right)$
57. (a) $0, 3, 4, \pm 1.414$ (b) 0
(c) $h(x) = x(x-4)(x-3)\left(x + \sqrt{2}\right)\left(x - \sqrt{2}\right)$
59. $2x^2 - x - 1,\ x \neq \frac{3}{2}$
61. (a)



(b) \$250,366
(c) Answers will vary.

63. False. $-\frac{4}{7}$ is a zero of f.
65. True. The degree of the numerator is greater than the degree of the denominator.
67. $k = -1$, not 1. **69.** $x^{2n} + 6x^n + 9,\quad x^n \neq -3$
71. $c = -210$ **73.** $k = 7$ **75.** $-\frac{5}{2}$ **77.** 4
79. $-\frac{5}{3}, \frac{3}{2}$ **81.** $\pm 5, 1$ **83.** $\pm\sqrt{2}, 0, \frac{1}{2}$ **85.** $2 + 5i$
87. $-1 - 6i$ **89.** $\pm 2i$ **91.** $-1 \pm \sqrt{6}i$
93. $-1 \pm \dfrac{\sqrt{5}}{2}i$ **95.** $(x^n + y^n)(x^n - y^n)$
97. *Sample answer:* $x^2 - 3$

Section 2.4 *(page 150)*

1. $\sqrt{-1}; -1$ **3.** (a) ii (b) iii (c) i
5. $-2 + 4i$ **7.** $a = 9, b = 8$
9. $7 + 4i$ **11.** 1 **13.** $3 - 3\sqrt{2}i$ **15.** $-12 + 9i$
17. $5 + i$ **19.** $108 + 12i$ **21.** 11 **23.** $-13 + 84i$
25. 85 **27.** 6 **29.** 20 **31.** 7 **33.** $\frac{8}{41} + \frac{10}{41}i$
35. $\frac{12}{13} + \frac{5}{13}i$ **37.** $-4 - 9i$ **39.** $-\frac{120}{1681} - \frac{27}{1681}i$
41. $-2\sqrt{3}$ **43.** -15 **45.** $7\sqrt{2}i$
47. $\left(21 + 5\sqrt{2}\right) + \left(7\sqrt{5} - 3\sqrt{10}\right)i$ **49.** $1 \pm i$

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51. $-2 \pm \frac{1}{2}i$ **53.** $-2 \pm \frac{\sqrt{5}}{2}i$ **55.** $2 \pm \sqrt{2}i$

57. $\frac{5}{7} \pm \frac{5\sqrt{13}}{7}i$ **59.** $z_1 = 5 + 2i, z_2 = 3 - 4i, z = \frac{53}{17} - \frac{33}{34}i$

61. False. *Sample answer:* $(1 + i) + (3 + i) = 4 + 2i$

63. True.

$$\begin{aligned} x^4 - x^2 + 14 &= 56 \\ \left(-i\sqrt{6}\right)^4 - \left(-i\sqrt{6}\right)^2 + 14 &\stackrel{?}{=} 56 \\ 36 + 6 + 14 &\stackrel{?}{=} 56 \\ 56 &= 56 \end{aligned}$$

65. $i, -1, -i, 1, i, -1, -i, 1$; The pattern repeats the first four results. Divide the exponent by 4.
When the remainder is 1, the result is i.
When the remainder is 2, the result is -1.
When the remainder is 3, the result is $-i$.
When the remainder is 0, the result is 1.

67. $\sqrt{-6}\sqrt{-6} = \sqrt{6}i\sqrt{6}i = 6i^2 = -6$

69. Proof **71.** $3x^2(x + 4)(x - 4)$ **73.** $(x - 3)(x^2 + 3)$

75. $3x(2x + 3)(x - 6)$ **77.** $(x + 1)(x - 1)(x^2 - 2)$

79. $(3x + 1)(3x - 1)(x + 2)(x - 2)$ **81.** (a) 4 (b) 2

83. (a) 0 (b) 0 **85.** (a) 25 (b) 25

87. (a) 0 (b) 0 **89.** (a) 0 (b) 4

Section 2.5 *(page 162)*

1. Fundamental Theorem of Algebra **3.** Rational Zero

5. five, three, or one **7.** 3 **9.** 5

11. 2 **13.** $\pm 1, \pm 2$

15. $\pm 1, \pm 3, \pm 5, \pm 9, \pm 15, \pm 45, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{5}{2}, \pm\frac{9}{2}, \pm\frac{15}{2}, \pm\frac{45}{2}$

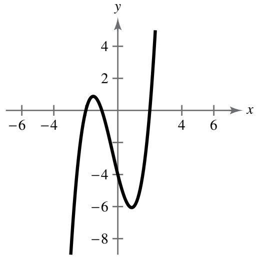
17. $-2, -1, 3$ **19.** No rational zeros **21.** $-6, -1$

23. $-1, \frac{1}{2}$ **25.** $-2, 3, \pm\frac{2}{3}$ **27.** $1, \frac{3}{5} \pm \frac{\sqrt{19}}{5}$

29. $-3, 1, -2 \pm \sqrt{6}$

31. (a) $\pm 1, \pm 2, \pm 4$

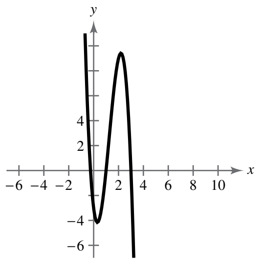
(b)



(c) $-2, -1, 2$

33. (a) $\pm 1, \pm 3, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{1}{4}, \pm\frac{3}{4}$

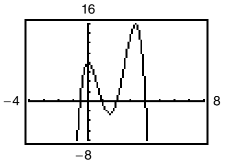
(b)



(c) $-\frac{1}{4}, 1, 3$

35. (a) $\pm 1, \pm 2, \pm 4, \pm 8, \pm\frac{1}{2}$

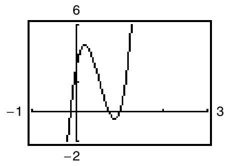
(b)



(c) $-\frac{1}{2}, 1, 2, 4$

37. (a) $\pm 1, \pm 3, \pm\frac{1}{2}, \pm\frac{3}{2}, \pm\frac{1}{4}, \pm\frac{3}{4}, \pm\frac{1}{8}, \pm\frac{3}{8}, \pm\frac{1}{16}, \pm\frac{3}{16}, \pm\frac{1}{32}, \pm\frac{3}{32}$

(b)



(c) $1, \frac{3}{4}, -\frac{1}{8}$

39. $f(x) = x^3 - x^2 + 25x - 25$

41. $f(x) = x^4 - 6x^3 + 14x^2 - 16x + 8$

43. $f(x) = 3x^4 - 17x^3 + 25x^2 + 23x - 22$

45. $f(x) = 2x^4 + 2x^3 - 2x^2 + 2x - 4$

47. $f(x) = x^3 + x^2 - 2x + 12$

49. (a) $(x^2 + 4)(x^2 - 2)$
(b) $(x^2 + 4)\left(x + \sqrt{2}\right)\left(x - \sqrt{2}\right)$
(c) $(x + 2i)(x - 2i)\left(x + \sqrt{2}\right)\left(x - \sqrt{2}\right)$

51. (a) $(x^2 - 6)(x^2 - 2x + 3)$
(b) $\left(x + \sqrt{6}\right)\left(x - \sqrt{6}\right)(x^2 - 2x + 3)$
(c) $\left(x + \sqrt{6}\right)\left(x - \sqrt{6}\right)\left(x - 1 - \sqrt{2}i\right)\left(x - 1 + \sqrt{2}i\right)$

53. $\pm 2i, 1$ **55.** $2, 3 \pm 2i$ **57.** $1, 3, 1 \pm \sqrt{2}i$

59. $(x + 6i)(x - 6i); \pm 6i$

61. $(x - 1 - 4i)(x - 1 + 4i); 1 \pm 4i$

63. $(x - 2)(x + 2)(x - 2i)(x + 2i); \pm 2, \pm 2i$

65. $(z - 1 + i)(z - 1 - i); 1 \pm i$

67. $(x + 1)(x - 2 + i)(x - 2 - i); -1, 2 \pm i$

69. $(x - 2)^2(x + 2i)(x - 2i); 2, \pm 2i$

71. $-10, -7 \pm 5i$ **73.** $-\frac{3}{4}, 1 \pm \frac{1}{2}i$ **75.** $-2, -\frac{1}{2}, \pm i$

77. One positive real zero, no negative real zeros

79. No positive real zeros, one negative real zero

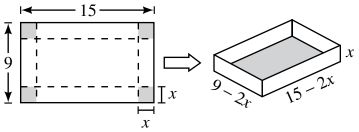
81. Two or no positive real zeros, two or no negative real zeros

83. Two or no positive real zeros, one negative real zero

85–87. Answers will vary. **89.** $\frac{3}{4}, \pm\frac{1}{2}$ **91.** $-\frac{3}{4}$

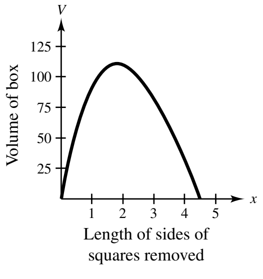
93. $\pm 2, \pm\frac{3}{2}$ **95.** $\pm 1, \frac{1}{4}$

97. (a)



(b) $V(x) = x(9 - 2x)(15 - 2x)$
Domain: $0 < x < \frac{9}{2}$

(c)



1.82 cm × 5.36 cm × 11.36 cm

(d) $\frac{1}{2}, \frac{7}{2}, 8$; 8 is not in the domain of V.

99. (a) $V(x) = x^3 + 9x^2 + 26x + 24 = 120$
(b) 4 ft × 5 ft × 6 ft

101. False. The most complex zeros it can have is two, and the Linear Factorization Theorem guarantees that there are three linear factors, so one zero must be real.

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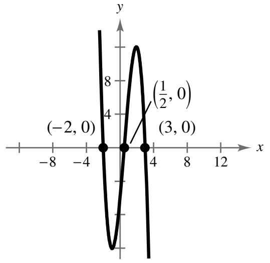
103. r_1, r_2, r_3 **105.** $5 + r_1, 5 + r_2, 5 + r_3$

107. The zeros cannot be determined.

109. Answers will vary. There are infinitely many possible functions for f. *Sample equation and graph:*

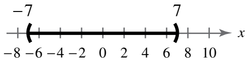
$f(x) = -2x^3 + 3x^2 + 11x - 6$



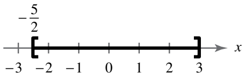
111. $f(x) = x^3 - 3x^2 + 4x - 2$

113. The function should be
$f(x) = (x + 2)(x - 3.5)(x + i)(x - i)$.

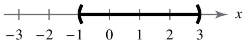
115. $-7 < x < 7$



117. $-\frac{5}{2} \le x \le 3$



119. $-1 < x < 3$



121. 4 **123.** $-\frac{1}{10}$ **125.** $\frac{8}{7}$ **127.** $-\frac{3}{2}$ **129.** $\frac{3}{2}$

131. $-\frac{4}{9}$ **133.** $\frac{3}{8}$

Section 2.6 *(page 175)*

1. rational functions **3.** Vertical asymptote

5. Domain: all real numbers x except $x = 1$
$f(x) \to -\infty$ as $x \to 1^-$, $f(x) \to \infty$ as $x \to 1^+$

7. Domain: all real numbers x except $x = \pm 1$
$f(x) \to \infty$ as $x \to -1^-$ and as $x \to 1^+$,
$f(x) \to -\infty$ as $x \to -1^+$ and as $x \to 1^-$

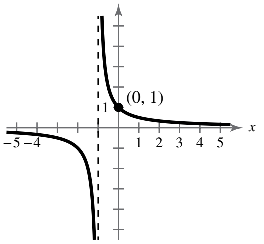
9. Vertical asymptote: $x = 0$
Horizontal asymptote: $y = 0$

11. Vertical asymptote: $x = 5$
Horizontal asymptote: $y = -1$

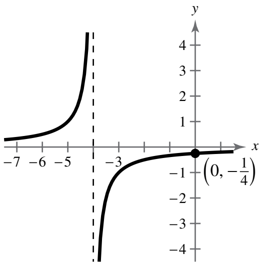
13. Vertical asymptote: $x = 1$

15. Vertical asymptote: $x = \frac{1}{2}$
Horizontal asymptote: $y = \frac{1}{2}$

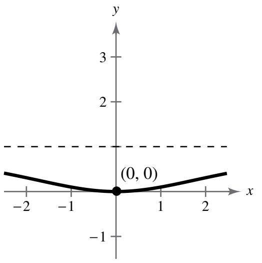
17. (a) Domain: all real numbers x except $x = -1$
(b) y-intercept: $(0, 1)$
(c) Vertical asymptote: $x = -1$
Horizontal asymptote: $y = 0$
(d)



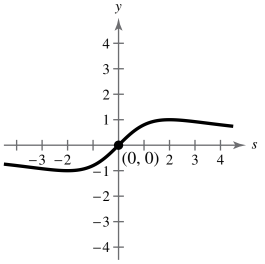
19. (a) Domain: all real numbers x except $x = -4$
(b) y-intercept: $\left(0, -\frac{1}{4}\right)$
(c) Vertical asymptote: $x = -4$
Horizontal asymptote: $y = 0$
(d)



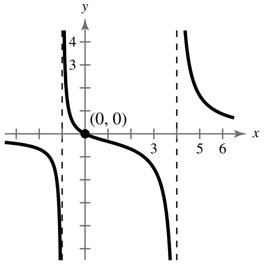
21. (a) Domain: all real numbers x (b) Intercept: $(0, 0)$
(c) Horizontal asymptote: $y = 1$
(d)



23. (a) Domain: all real numbers s (b) Intercept: $(0, 0)$
(c) Horizontal asymptote: $y = 0$
(d)



25. (a) Domain: all real numbers x except $x = 4, -1$
(b) Intercept: $(0, 0)$
(c) Vertical asymptotes: $x = -1, x = 4$
Horizontal asymptote: $y = 0$
(d)



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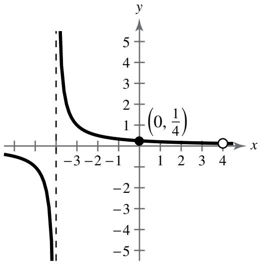
27. (a) Domain: all real numbers x except $x = \pm 4$

(b) y-intercept: $\left(0, \frac{1}{4}\right)$

(c) Vertical asymptote: $x = -4$

Horizontal asymptote: $y = 0$

(d)



29. (a) Domain: all real numbers x except $x = -1, 5$

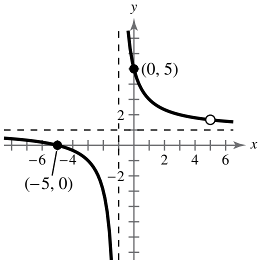
(b) x-intercept: $(-5, 0)$

y-intercept: $(0, 5)$

(c) Vertical asymptote: $x = -1$

Horizontal asymptote: $y = 1$

(d)



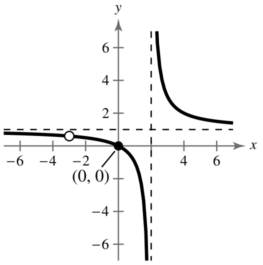
31. (a) Domain: all real numbers x except $x = 2, -3$

(b) Intercept: $(0, 0)$

(c) Vertical asymptote: $x = 2$

Horizontal asymptote: $y = 1$

(d)



33. (a) Domain: all real numbers x except $x = \pm 1, 2$

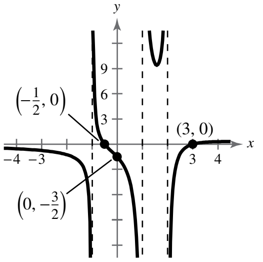
(b) x-intercepts: $(3, 0), \left(-\frac{1}{2}, 0\right)$

y-intercept: $\left(0, -\frac{3}{2}\right)$

(c) Vertical asymptotes: $x = 2, x = \pm 1$

Horizontal asymptote: $y = 0$

(d)

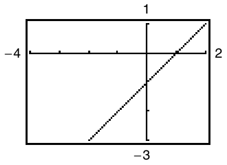


35. d **36.** a **37.** c **38.** b

39. (a) Domain of f: all real numbers x except $x = -1$

Domain of g: all real numbers x

(b)

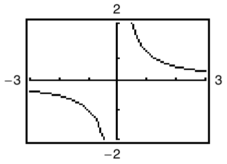


(c) Because there are only a finite number of pixels, the graphing utility may not attempt to evaluate the function where it does not exist.

41. (a) Domain of f: all real numbers x except $x = 0, 2$

Domain of g: all real numbers x except $x = 0$

(b)



(c) Because there are only a finite number of pixels, the graphing utility may not attempt to evaluate the function where it does not exist

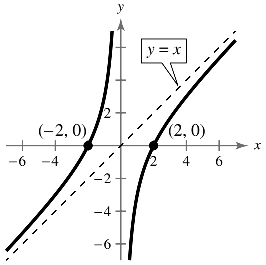
43. (a) Domain: all real numbers x except $x = 0$

(b) x-intercepts: $(\pm 2, 0)$

(c) Vertical asymptote: $x = 0$

Slant asymptote: $y = x$

(d)



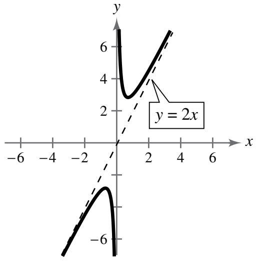
45. (a) Domain: all real numbers x except $x = 0$

(b) No intercepts

(c) Vertical asymptote: $x = 0$

Slant asymptote: $y = 2x$

(d)



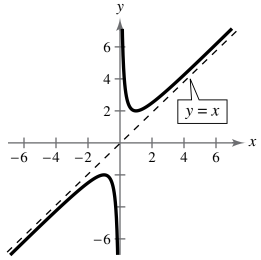
47. (a) Domain: all real numbers x except $x = 0$

(b) No intercepts

(c) Vertical asymptote: $x = 0$

Slant asymptote: $y = x$

(d)



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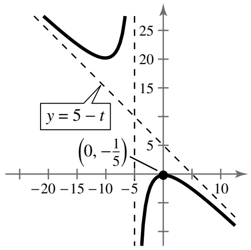
49. (a) Domain: all real numbers t except $t = -5$

(b) y-intercept: $\left(0, -\frac{1}{5}\right)$

(c) Vertical asymptote: $t = -5$

Slant asymptote: $y = -t + 5$

(d)



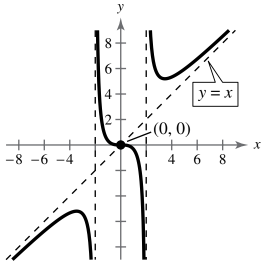
51. (a) Domain: all real numbers x except $x = \pm 2$

(b) Intercept: $(0, 0)$

(c) Vertical asymptotes: $x = \pm 2$

Slant asymptote: $y = x$

(d)



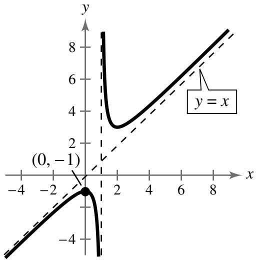
53. (a) Domain: all real numbers x except $x = 1$

(b) y-intercept: $(0, -1)$

(c) Vertical asymptote: $x = 1$

Slant asymptote: $y = x$

(d)



55. (a) Domain: all real numbers x except $x = -1, -2$

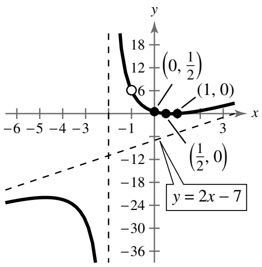
(b) y-intercept: $\left(0, \frac{1}{2}\right)$

x-intercepts: $\left(\frac{1}{2}, 0\right)$, $(1, 0)$

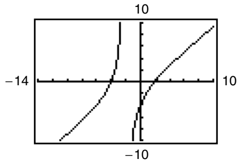
(c) Vertical asymptote: $x = -2$

Slant asymptote: $y = 2x - 7$

(d)



57.



Domain: all real numbers

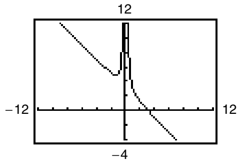
x except $x = -2$

Vertical asymptote: $x = -2$

Slant asymptote: $y = x$

$y = x$

59.



Domain: all real numbers x except $x = 0$

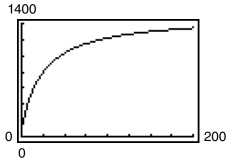
Vertical asymptote: $x = 0$

Slant asymptote: $y = -x + 3$

$y = -x + 3$

61. (a) $(-1, 0)$ (b) -1 **63.** 12.8 in. × 8.5 in.

65. (a)



(b) 333 deer; 500 deer; 800 deer

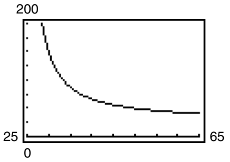
(c) 1500 deer

67. (a) Answers will vary.

(b) Vertical asymptote: $x = 25$

Horizontal asymptote: $y = 25$

(c)



(d)

x	30	35	40	45	50	55	60
y	150	87.5	66.7	56.3	50	45.8	42.9

(e) *Sample answer:* No. You might expect the average speed for the round trip to be the average of the average speeds for the two parts of the trip.

(f) No. At 20 miles per hour you would use more time in one direction than is required for the round trip at an average speed of 50 miles per hour.

69. False. Polynomials do not have vertical asymptotes.

71. Yes; No; Every rational function is the ratio of two polynomial functions of the form $f(x) = \dfrac{N(x)}{D(x)}$.

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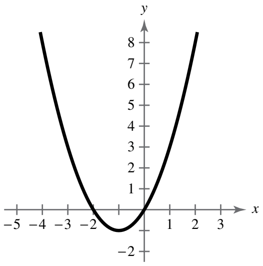
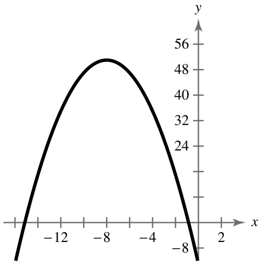
73. $f(x) = (x + 1)^2 - 1$ **75.** $f(x) = -(x + 8)^2 + 51$





Vertex: $(-1, -1)$
Axis of symmetry: $x = -1$
x-intercepts: $(-2, 0), (0, 0)$

Vertex: $(-8, 51)$
Axis of symmetry: $x = -8$
x-intercept: $(-8 \pm \sqrt{51}, 0)$

77. x-intercepts: $(-10, 0), (-2, 0)$
y-intercept: $(0, 20)$

79. x-intercept: $\left(-\frac{3}{2}, 0\right)$
y-intercept: $(0, 3)$

81. Intercept: $(0, 0)$

83. x-intercept: $(-3, 0)$
y-intercept: $\left(0, \frac{3}{2}\right)$

85. $\dfrac{1 \pm \sqrt{41}}{4}$ **87.** $-\dfrac{17}{22}$

Section 2.7 *(page 185)*

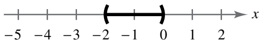
1. positive; negative **3.** $-2, 5$

5. (a) No (b) Yes (c) Yes (d) No

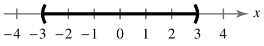
7. (a) Yes (b) No (c) No (d) Yes

9. $-3, 6$ **11.** $4, 5$

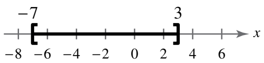
13. $(-2, 0)$



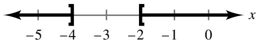
15. $(-3, 3)$



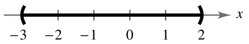
17. $[-7, 3]$



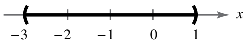
19. $(-\infty, -4] \cup [-2, \infty)$



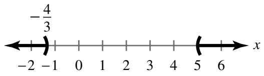
21. $(-3, 2)$



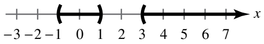
23. $(-3, 1)$



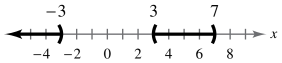
25. $\left(-\infty, -\frac{4}{3}\right) \cup (5, \infty)$



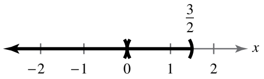
27. $(-1, 1) \cup (3, \infty)$



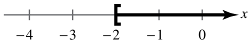
29. $(-\infty, -3) \cup (3, 7)$



31. $(-\infty, 0) \cup \left(0, \frac{3}{2}\right)$



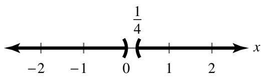
33. $[-2, \infty)$



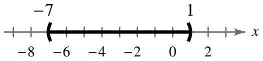
35. The solution set consists of the single real number $\frac{1}{2}$.

37. The solution set is empty.

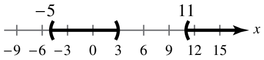
39. $(-\infty, 0) \cup \left(\frac{1}{4}, \infty\right)$



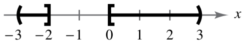
41. $(-7, 1)$



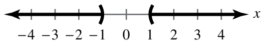
43. $(-5, 3) \cup (11, \infty)$



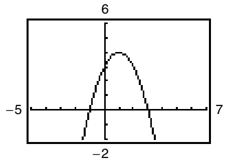
45. $(-3, -2] \cup [0, 3)$



47. $(-\infty, -1) \cup (1, \infty)$

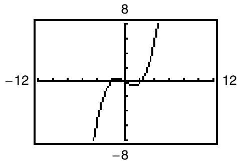


49.



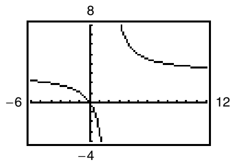
(a) $x \le -1, x \ge 3$
(b) $0 \le x \le 2$

51.



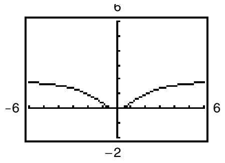
(a) $-2 \le x \le 0,$
$2 \le x \le \infty$
(b) $x \le 4$

53.



(a) $0 \le x < 2$
(b) $2 < x \le 4$

55.



(a) $|x| \ge 2$
(b) $-\infty < x < \infty$

57. $(-3.89, 3.89)$ **59.** $(-0.13, 25.13)$ **61.** $(2.26, 2.39)$

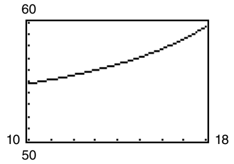
63. (a) $t = 10$ sec (b) 4 sec $< t <$ 6 sec

65. $40{,}000 \le x \le 50{,}000$; $\$50.00 \le p \le \$55.00$

67. $[-2, 2]$ **69.** $(-\infty, 4] \cup [5, \infty)$

71. $(-5, 0] \cup (7, \infty)$

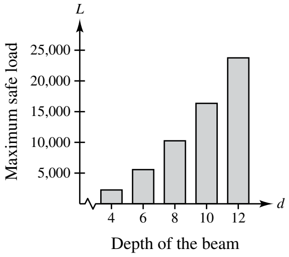
73. (a)



(b) $t < 14.9$ (2014)
(c) *Sample answer:* No. For $t > 22$, the model rapidly increases then decreases.

75. (a)

d	4	6	8	10	12
Load	2223.9	5593.9	10,312	16,378	23,792



(b) 3.83 in.

77. 13.8 m $\le L \le$ 36.2 m

79. False. There are four test intervals.

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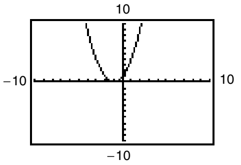
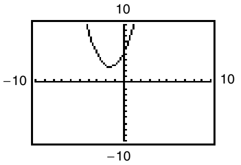
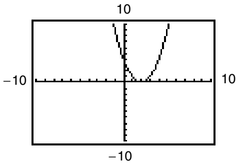
81.



For part (b), the y-values that are less than or equal to 0 occur only at $x = -1$.



For part (c), there are no y-values that are less than 0.



For part (d), the y-values that are greater than 0 occur for all values of x except 2.

83. $1/x$ is undefined when $x = 0$, so the solution set is $(0, \infty)$.

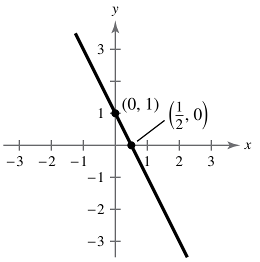
85. (a) $(-\infty, -6] \cup [6, \infty)$
(b) When $a > 0$ and $c > 0$, $b \le -2\sqrt{ac}$ or $b \ge 2\sqrt{ac}$.

87. (a) $\left(-\infty, -2\sqrt{30}\right] \cup \left[2\sqrt{30}, \infty\right)$
(b) When $a > 0$ and $c > 0$, $b \le -2\sqrt{ac}$ or $b \ge 2\sqrt{ac}$.

89. $\frac{1}{3}$ **91.** 0

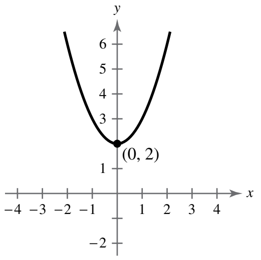
93. x-intercept: $(-1, 0)$
y-intercept: $(0, 1)$

95. No symmetry



x-intercept: $\left(\frac{1}{2}, 0\right)$
y-intercept: $(0, 1)$

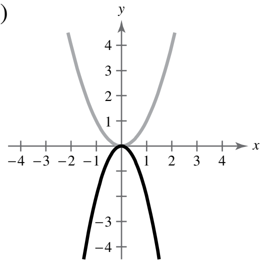
97. y-axis symmetry



No x-intercepts
y-intercept: $(0, 2)$

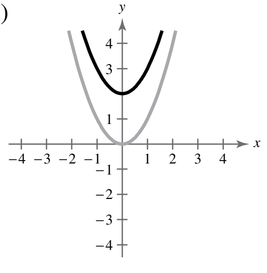
Review Exercises *(page 190)*

1. (a)



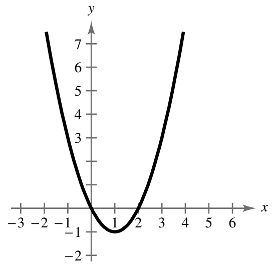
Vertical stretch and a reflection in the x-axis

(b)



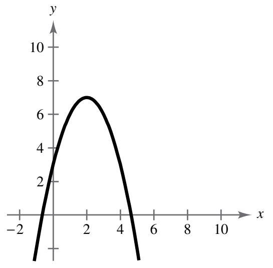
Upward shift of two units

3. $g(x) = (x - 1)^2 - 1$



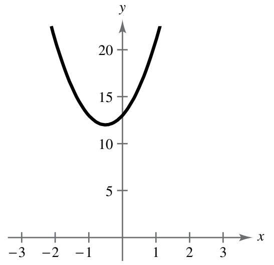
Vertex: $(1, -1)$
Axis of symmetry: $x = 1$
x-intercepts: $(0, 0)$, $(2, 0)$

5. $h(x) = -(x - 2)^2 + 7$



Vertex: $(2, 7)$
Axis of symmetry: $x = 2$
x-intercepts: $\left(2 \pm \sqrt{7}, 0\right)$

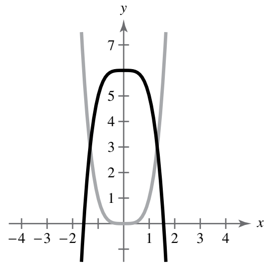
7. $h(x) = 4\left(x + \frac{1}{2}\right)^2 + 12$



Vertex: $\left(-\frac{1}{2}, 12\right)$
Axis of symmetry: $x = -\frac{1}{2}$
No x-intercept

9. (a) $y = 500 - x$
$A(x) = 500x - x^2$
(b) $x = 250$, $y = 250$

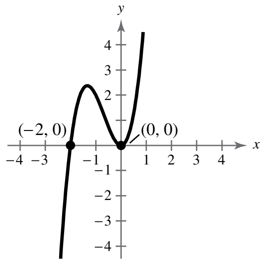
11.



13. Falls to the left and to the right

15. Falls to the left, rises to the right

17. (a) Falls to the left, rises to the right
(b) $-2, 0$ (c) Answers will vary.
(d)



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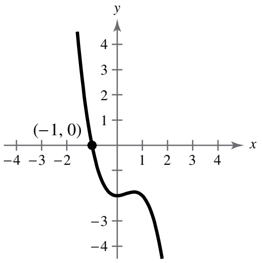
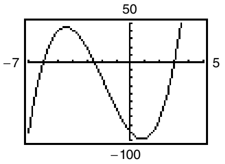
19. (a) Rises to the left, falls to the right
(b) -1 (c) Answers will vary.
(d)



21. (a) $[-1, 0]$ (b) -0.900

23. $6x + 3 + \dfrac{17}{5x - 3}$ **25.** $2x^2 - 9x - 6, x \neq 8$

27. (a) Answers will vary. (b) $(2x + 5), (x - 3)$
(c) $f(x) = (2x + 5)(x - 3)(x + 6)$ (d) $-\frac{5}{2}, 3, -6$
(e)



29. $4 + 3i$ **31.** $-3 - 3i$ **33.** $15 + 6i$ **35.** $\frac{4}{5} + \frac{8}{5}i$

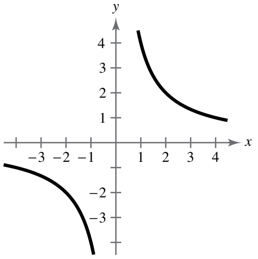
37. $\frac{21}{13} - \frac{1}{13}i$ **39.** $1 \pm 3i$ **41.** 2 **43.** $-1, \dfrac{7}{4}, 6$

45. $2, \pm 4i$

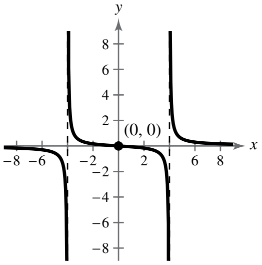
47. One or three positive real zeros, two or no negative real zeros

49. Domain: all real numbers x except $x = -10$
Vertical asymptote: $x = -10$
Horizontal asymptote: $y = 3$

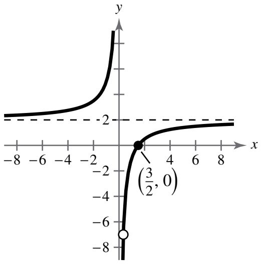
51. (a) Domain: all real numbers x except $x = 0$
(b) No intercepts
(c) Vertical asymptote: $x = 0$
Horizontal asymptote: $y = 0$
(d)



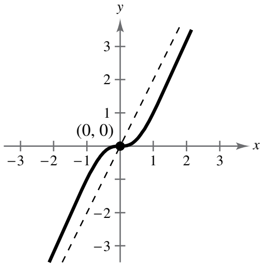
53. (a) Domain: all real numbers x except $x = \pm 4$
(b) Intercept: $(0, 0)$
(c) Vertical asymptotes: $x = \pm 4$
Horizontal asymptote: $y = 0$
(d)



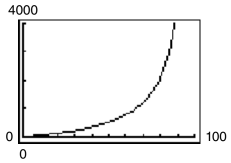
55. (a) Domain: all real numbers x except $x = 0, \frac{1}{3}$
(b) x-intercept: $\left(\frac{3}{2}, 0\right)$
(c) Vertical asymptote: $x = 0$
Horizontal asymptote: $y = 2$
(d)



57. (a) Domain: all real numbers x
(b) Intercept: $(0, 0)$ (c) Slant asymptote: $y = 2x$
(d)

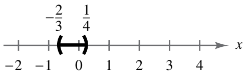


59. (a)

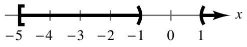


(b) \$176 million; \$528 million; \$1584 million (or \$1.584 billion)
(c) No; The function is undefined when $p = 100$.

61. $\left(-\frac{2}{3}, \frac{1}{4}\right)$



63. $[-5, -1) \cup (1, \infty)$

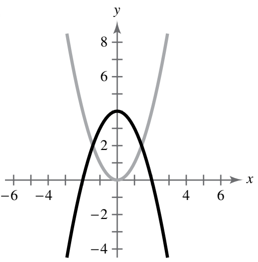


65. 9 days

67. False. The domain of $f(x) = \dfrac{1}{x^2 + 1}$ is the set of all real numbers.

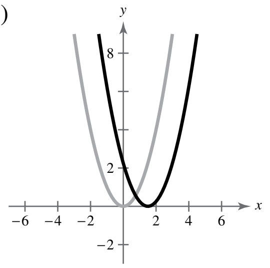
Chapter Test *(page 192)*

1. (a)



Reflection in the x-axis and an upward shift of four units

(b)



Right shift of $\frac{3}{2}$ units

2. $y = (x - 3)^2 - 6$

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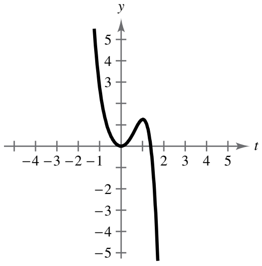
3. (a) 50 ft
 (b) 5. Yes, changing the constant term results in a vertical shift of the graph, so the maximum height changes.

4. Rises to the left, falls to the right



5. $3x + \frac{x-1}{x^2+1}$ **6.** $2x^3 - 4x^2 + 5x - 6 + \frac{11}{x+2}$

7. $(2x-5)(x+\sqrt{3})(x-\sqrt{3})$; Zeros: $\frac{5}{2}, \pm\sqrt{3}$

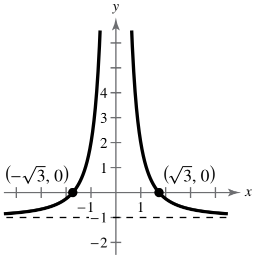
8. (a) -14 (b) $19 + 17i$ **9.** $\frac{8}{5} - \frac{16}{5}i$

10. $f(x) = x^4 - 2x^3 + 9x^2 - 18x$

11. $f(x) = x^4 - 6x^3 + 16x^2 - 18x + 7$

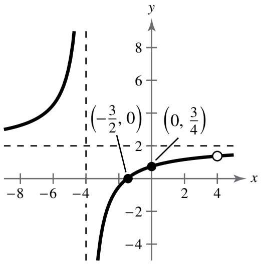
12. $-5, -\frac{2}{3}, 1$ **13.** $-2, 4, -1 \pm \sqrt{2}i$

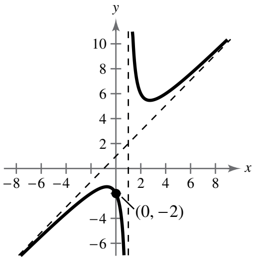
14. x-intercepts: $(\pm\sqrt{3}, 0)$
Vertical asymptote: $x = 0$
Horizontal asymptote: $y = -1$



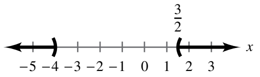
15. x-intercept: $\left(-\frac{3}{2}, 0\right)$
y-intercept: $\left(0, \frac{3}{4}\right)$
Vertical asymptote: $x = -4$
Horizontal asymptote: $y = 2$

16. y-intercept: $(0, -2)$
Vertical asymptote: $x = 1$
Slant asymptote: $y = x + 1$

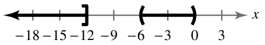




17. $x < -4$ or $x > \frac{3}{2}$



18. $x \le -12$ or $-6 < x < 0$



Problem Solving *(page 195)*

1. Answers will vary. **3.** 2 in. × 2 in. × 5 in.

5. (a) and (b) $y = -x^2 + 5x - 4$

7. (a) $f(x) = (x-2)x^2 + 5 = x^3 - 2x^2 + 5$
 (b) $f(x) = -(x+3)x^2 + 1 = -x^3 - 3x^2 + 1$

9. $$(a+bi)(a-bi) = a^2 + abi - abi - b^2i^2$$ $$= a^2 + b^2$$

11. (a) As $|a|$ increases, the graph stretches vertically. For $a < 0$, the graph is reflected in the x-axis.
 (b) As $|b|$ increases, the vertical asymptote is translated. For $b > 0$, the graph is translated to the right. For $b < 0$, the graph is reflected in the x-axis and is translated to the left.

13. No. Complex zeros always occur in conjugate pairs.

Chapter 3

Section 3.1 *(page 206)*

1. transcendental

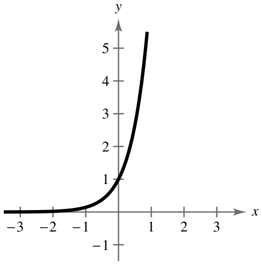
3. Horizontal translation one unit to the left

5. 0.863 **7.** 1767.767

9. d **10.** c **11.** a **12.** b

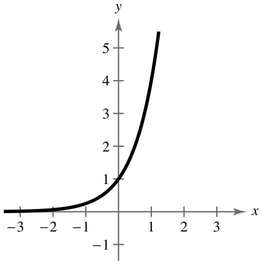
13.

x	-2	-1	0	1	2
$f(x)$	0.020	0.143	1	7	49



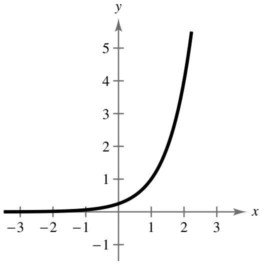
15.

x	-2	-1	0	1	2
$f(x)$	0.063	0.25	1	4	16



17.

x	-2	-1	0	1	2
$f(x)$	0.016	0.063	0.25	1	4



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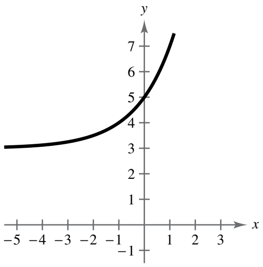
19.

x	-3	-2	-1	0	1
$f(x)$	3.25	3.5	4	5	7



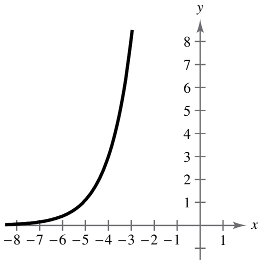
21. 2 **23.** -5 **25.** Shift the graph of f one unit up.

27. Reflect the graph of f in the y-axis and shift three units to the right.

29. 6.686 **31.** 7166.647

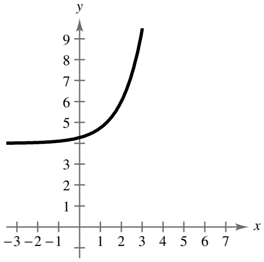
33.

x	-8	-7	-6	-5	-4
$f(x)$	0.055	0.149	0.406	1.104	3

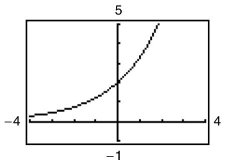


35.

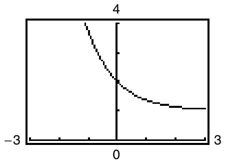
x	-2	-1	0	1	2
$f(x)$	4.037	4.100	4.271	4.736	6



37.



39.



41. $\frac{1}{3}$ **43.** 3, -1

45.

n	1	2	4	12
A	\$1828.49	\$1830.29	\$1831.19	\$1831.80

n	365	Continuous
A	\$1832.09	\$1832.10

47.

n	1	2	4	12
A	\$5477.81	\$5520.10	\$5541.79	\$5556.46

n	365	Continuous
A	\$5563.61	\$5563.85

49.

t	10	20	30
A	\$17,901.90	\$26,706.49	\$39,841.40

t	40	50
A	\$59,436.39	\$88,668.67

51.

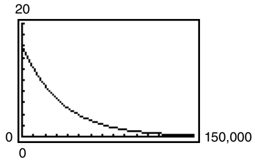
t	10	20	30
A	\$22,986.49	\$44,031.56	\$84,344.25

t	40	50
A	\$161,564.86	\$309,484.08

53. \$104,710.29 **55.** \$44.23

57. (a) 16 g (b) 1.85 g

(c)

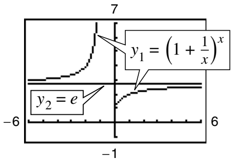


59. (a) $V(t) = 52{,}490\left(\frac{7}{8}\right)^t$ (b) About 30,769 infections

61. True. As $x \to -\infty$, $f(x) \to -2$ but never reaches -2.

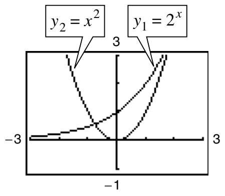
63. $f(x) = h(x)$ **65.** $f(x) = g(x) = h(x)$

67.

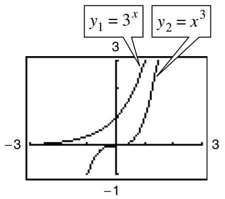


As the x-value increases, y_1 approaches the value of e.

69. (a)



(b)



In both viewing windows, the constant raised to a variable power increases more rapidly than the variable raised to a constant power.

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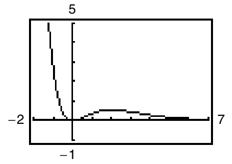
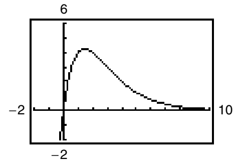
71. (a)



Decreasing: $(-\infty, 0), (2, \infty)$
Increasing: $(0, 2)$
Relative maximum: $(2, 4e^{-2})$
Relative minimum: $(0, 0)$

(b)

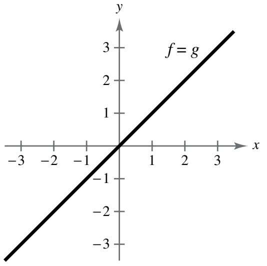


Decreasing: $(1.44, \infty)$
Increasing: $(-\infty, 1.44)$
Relative maximum: $(1.44, 4.25)$

73. c, d

75. (a) $f(g(x)) = f(x) = x$
$g(f(x)) = g(x) = x$

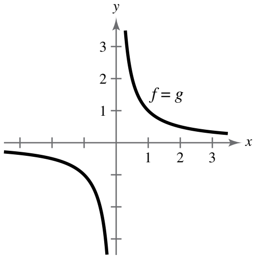
(b)



77. (a) $f(g(x)) = f\left(\frac{1}{x}\right) = \frac{1}{(1/x)} = x$

$g(f(x)) = g\left(\frac{1}{x}\right) = \frac{1}{(1/x)} = x$

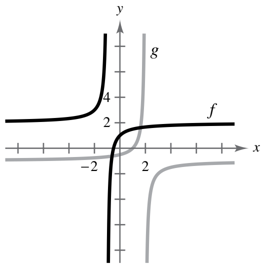
(b)



79. (a) $f(g(x)) = f\left(\frac{1-x}{x-2}\right) = \frac{2\left(\frac{1-x}{x-2}\right) + 1}{\frac{1-x}{x-2} + 1} = x$

$g(f(x)) = g\left(\frac{2x+1}{x+1}\right) = \frac{1 - \frac{2x+1}{x+1}}{\frac{2x+1}{x+1} - 2} = x$

(b)



81. $f^{-1}(x) = x - 2$
The domain of f and the range of f^{-1} are all real numbers x such that $x \geq -2$. The domain of f^{-1} and the range of f are all real numbers x such that $x \geq 0$.

83. $f^{-1}(x) = \sqrt{x} - 6$
The domain of f and the range of f^{-1} are all real numbers x such that $x \geq -6$. The domain of f^{-1} and the range of f are all real numbers x such that $x \geq 0$.

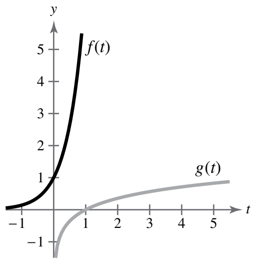
85. $f^{-1}(x) = \frac{\sqrt{-2(x-5)}}{2}$
The domain of f and the range of f^{-1} are all real numbers x such that $x \geq 0$. The domain of f^{-1} and the range of f are all real numbers x such that $x \leq 5$.

87. $f^{-1}(x) = x + 3$
The domain of f and the range of f^{-1} are all real numbers x such that $x \geq 4$. The domain of f^{-1} and the range of f are all real numbers x such that $x \geq 1$.

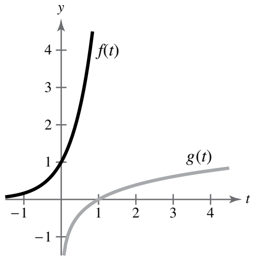
Section 3.2 *(page 216)*

1. logarithmic **3.** natural; e **5.** (a) x (b) y^2
7. $4^2 = 16$ **9.** $9^{-2} = \frac{1}{81}$ **11.** $\log_5 125 = 3$
13. $\log_4 \frac{1}{64} = -3$ **15.** 6 **17.** 1 **19.** $\frac{1}{2}$
21. 1.097 **23.** −0.058 **25.** 1 **27.** 2
29. 5 **31.** ±2

33.



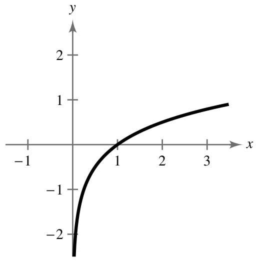
35.



37. a; Upward shift of two units

39. b; Reflection in the y-axis and a right shift of one unit

41.



Domain: $(0, \infty)$
x-intercept: $(1, 0)$
Vertical asymptote: $x = 0$

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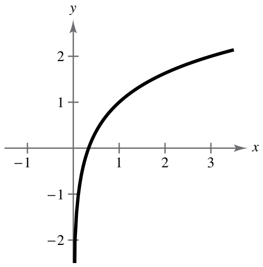
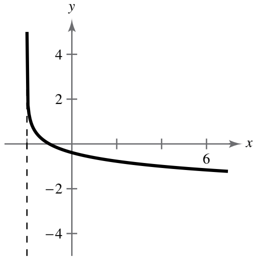
43.



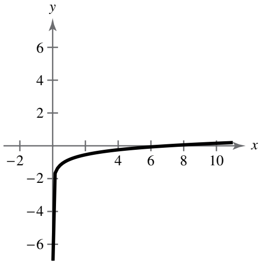
Domain: $(0, \infty)$
x-intercept: $\left(\frac{1}{3}, 0\right)$
Vertical asymptote: $x = 0$

45.



Domain: $(-2, \infty)$
x-intercept: $(-1, 0)$
Vertical asymptote: $x = -2$

47.



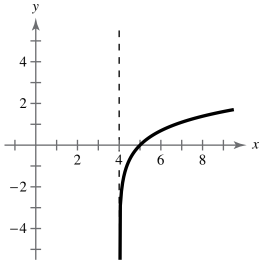
Domain: $(0, \infty)$
x-intercept: $(7, 0)$
Vertical asymptote: $x = 0$

49. $e^{-0693\ldots} = \frac{1}{2}$ **51.** $e^{5.521\ldots} = 250$

53. $\ln 7.3890\ldots = 2$ **55.** $\ln \frac{1}{2} = -4x$ **57.** 23.123

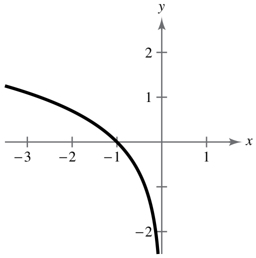
59. 6.438 **61.** 4 **63.** 0 **65.** 1

67.



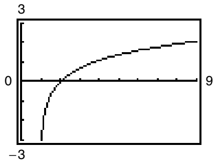
Domain: $(4, \infty)$
x-intercept: $(5, 0)$
Vertical asymptote: $x = 4$

69.



Domain: $(-\infty, 0)$
x-intercept: $(-1, 0)$
Vertical asymptote: $x = 0$

71.



73. 8 **75.** −2, 3

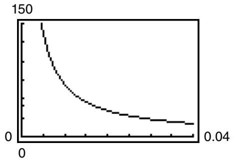
77. (a) 30 yr; 10 yr
(b) \$323,179; \$199,109; \$173,179; \$49,109
(c) $x = 750$; The monthly payment must be greater than \$750.

79. (a)

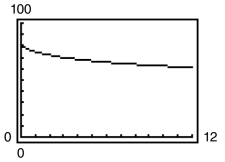
r	0.005	0.010	0.015	0.020	0.025	0.030
t	138.6	69.3	46.2	34.7	27.7	23.1

As the rate of increase r increases, the time t in years for the population to double decreases.

(b)

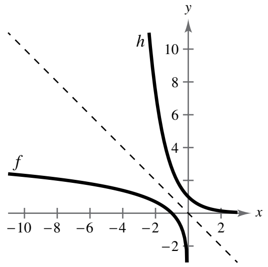


81. (a)



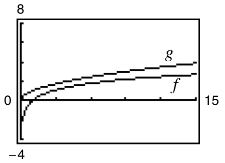
(b) 80 (c) 68.1 (d) 62.3

83. True.



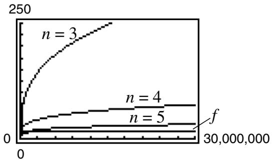
85. $\frac{1}{9}$ **87.** $y = \log_2 x$, so y is a logarithmic function of x.

89. (a)



(b) $g(x)$

(c)



As n increases, $g(x) = x^{1/n}$ increases at a slower rate.

91. $x^3y^5, x \neq 0$ **93.** $\dfrac{m^3}{n}, m \neq 0$

95. $5x + 3, x \neq 4$ **97.** $-x^3 - 6x^2 - 36x - 36 - \dfrac{216}{x - 6}$

99. (a) $4x - 2$ (b) $4x - 11$ (c) $16x + 5$

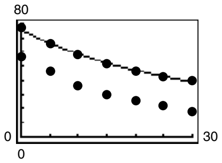
101. (a) $\sqrt{\dfrac{1}{x^2} - 9}$ (b) $-\dfrac{1}{\sqrt{x^2 - 9}}$ (c) $x, x \neq 0$

Section 3.3 *(page 223)*

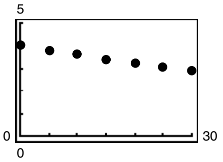
1. change-of-base **3.** $\log_3 24 = \dfrac{\ln 24}{\ln 3}$

5. (a) $\dfrac{\log 16}{\log 5}$ (b) $\dfrac{\ln 16}{\ln 5}$ **7.** (a) $\dfrac{\log \frac{3}{10}}{\log x}$ (b) $\dfrac{\ln \frac{3}{10}}{\ln x}$

9. 2.579 **11.** -0.606 **13.** $\log_3 5 + \log_3 7$
15. $\log_3 7 - 2\log_3 5$ **17.** $1 + \log_3 7 - \log_3 5$
19. 2 **21.** $-\frac{1}{3}$ **23.** -2 is not in the domain of $\log_2 x$.
25. $\frac{3}{4}$ **27.** 7 **29.** 2 **31.** $\frac{3}{2}$ **33.** 1.1833
35. -1.6542 **37.** 1.9563 **39.** -2.7124
41. $\ln 7 + \ln x$ **43.** $4\log_8 x$ **45.** $1 - \log_5 x$
47. $\frac{1}{2}\ln z$ **49.** $\ln x + \ln y + 2\ln z$ **51.** $\ln z + 2\ln(z - 1)$
53. $\frac{1}{2}\log_2(a + 2) + \frac{1}{2}\log_2(a - 2) - \log_2 7$
55. $2\log_5 x - 2\log_5 y - 3\log_5 z$ **57.** $\ln x - \frac{3}{2}\ln y$
59. $2\ln x + \frac{1}{2}\ln y - \frac{1}{2}\ln z$
61. $\frac{3}{4}\ln x + \frac{1}{4}\ln(x^2 + 3)$ **63.** $\ln 3x$
65. $\log_7(z - 2)^{2/3}$ **67.** $\log_3 \dfrac{5}{x^3}$ **69.** $\log x(x + 1)^2$
71. $\log \dfrac{xz^3}{y^2}$ **73.** $\ln \dfrac{x}{(x + 1)(x - 1)}$ **75.** $\ln\sqrt{\dfrac{x(x + 3)^2}{x^2 - 1}}$
77. $\ln y = -\frac{1}{4}\ln x + \ln\frac{5}{2}$ **79.** $\ln y = -0.14\ln x + 5.7$
81. (a) and (b)

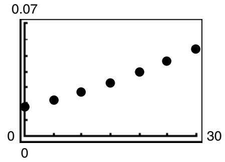


(c)



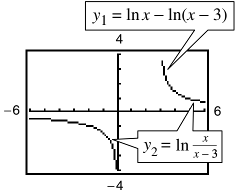
$T = 21 + e^{-0.037t + 3.997}$
The results are similar.

(d)



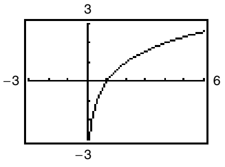
$$T = 21 + \frac{1}{0.001t + 0.016}$$

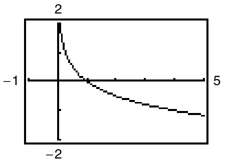
83. False; $\ln 1 = 0$ **85.** False; $\ln(x - 2) \neq \ln x - \ln 2$
87. False; $u = v^2$
89. The Power Property cannot be used because $\ln e$ is raised to the second power, not just e.
91.



No; $\dfrac{x}{x - 3} > 0$ when $x < 0$.

93. $\log_2 \frac{32}{4} = \log_2 32 - \log_2 4$; Property 2
95. $f(x) = \dfrac{\log x}{\log 2} = \dfrac{\ln x}{\ln 2}$ **97.** $f(x) = \dfrac{\log x}{\log \frac{1}{4}} = \dfrac{\ln x}{\ln \frac{1}{4}}$





99. $\ln 1 = 0$
$\ln 2 \approx 0.6931$
$\ln 3 \approx 1.0986$
$\ln 4 \approx 1.3862$
$\ln 5 \approx 1.6094$
$\ln 6 \approx 1.7917$
$\ln 8 \approx 2.0793$
$\ln 9 \approx 2.1972$
$\ln 10 \approx 2.3025$
$\ln 12 \approx 2.4848$
$\ln 15 \approx 2.7080$
$\ln 16 \approx 2.7724$
$\ln 18 \approx 2.8903$
$\ln 20 \approx 2.9956$
101. $x = -8, x = 3$ **103.** $x = 1, x = 9$ **105.** 4
107. -3 **109.** 0, 5 **111.** $-1, 4$ **113.** -4
115. (a) Yes (b) Yes **117.** (a) Yes (b) No
119. (a) Yes (b) No

Section 3.4 *(page 233)*

1. (a) $x = y$ (b) $x = y$ (c) x (d) x
3. Rewrite 125 as 5^3. By the One-to-One Property, $x = 3$.
5. (a) No (b) Yes **7.** (a) Yes (b) No
9. 2 **11.** 2 **13.** $\ln 2 \approx 0.693$ **15.** $e^{-1} \approx 0.368$
17. 64 **19.** (3, 8) **21.** $2, -1$
23. $\dfrac{\ln 5}{\ln 3} \approx 1.465$ **25.** $\ln 39 \approx 3.664$
27. $2 - \dfrac{\ln 400}{\ln 3} \approx -3.454$ **29.** $\dfrac{1}{3}\log\dfrac{3}{2} \approx 0.059$
31. $\dfrac{\ln 12}{3} \approx 0.828$ **33.** 0 **35.** $\dfrac{\ln \frac{8}{3}}{3\ln 2} + \dfrac{1}{3} \approx 0.805$
37. $0, \dfrac{\ln 4}{\ln 5} \approx 0.861$ **39.** $\ln 5 \approx 1.609$
41. $\ln\frac{4}{5} \approx -0.223$ **43.** $\dfrac{\ln 4}{365\ln\left(1 + \dfrac{0.065}{365}\right)} \approx 21.330$
45. $e^{-3} \approx 0.050$ **47.** $\dfrac{e^{2.1}}{6} \approx 1.361$ **49.** $e^{-2} \approx 0.135$
51. $2(3^{11/6}) \approx 14.988$ **53.** No solution
55. No solution **57.** 2 **59.** 3.328
61. -0.478 **63.** 20.086 **65.** 1.482
67. (a) 27.73 yr (b) 43.94 yr **69.** $-1, 0$ **71.** 1
73. $e^{-1} \approx 0.368$ **75.** $e^{-1/2} \approx 0.607$
77. (a) $y = 100$ and $y = 0$; The range falls between 0% and 100%.
(b) Males: 69.51 in. Females: 64.49 in.
79. 5 years **81.** 2013
83. For $rt < \ln 2$ years, double the amount you invest. For $rt > \ln 2$ years, double your interest rate or double the number of years, because either of these will double the exponent in the exponential function.
85. $\log_b uv = \log_b u + \log_b v$
True by Property 1 in Section 3.3.
87. $\log_b(u - v) = \log_b u - \log_b v$
False.
$1.95 \approx \log(100 - 10) \neq \log 100 - \log 10 = 1$
89. Yes. See Exercise 55.
91. Vertical asymptote: $x = 1$
Horizontal asymptote: $y = 1$
93. $1 - \dfrac{3}{\ln 2}$ **95.** $0, \pm\dfrac{\sqrt{8 + \ln 3}}{4}$ **97.** $\dfrac{100}{x^6}$

Section 3.5 *(page 243)*

1. $y = a + b \ln x$; $y = a + b \log x$

3. An exponential growth model increases over time. An exponential decay model decreases over time.

5. $P = \dfrac{A}{e^{rt}}$; $t = \dfrac{\ln\left(\dfrac{A}{P}\right)}{r}$

7. 19.8 yr; \$1419.07 **9.** 8.9438%; \$1834.37

11. \$6376.28; 15.4 yr

13. (a) 7.27 yr (b) 6.96 yr (c) 6.93 yr (d) 6.93 yr

15. (a)

r	2%	4%	6%	8%	10%	12%
t	54.93	27.47	18.31	13.73	10.99	9.16

(b)

r	2%	4%	6%	8%	10%	12%
t	55.48	28.01	18.85	14.27	11.53	9.69

17. The values given by the model are close to the original data values; November

19. $y = e^{0.7675x}$ **21.** $y = 5e^{-0.4024x}$ **23.** 6.48 g

25. 2.26 g

27. (a) Bulgaria: $y = 8.1e^{-0.00741t}$; 6.1 million

Canada: $y = 32.9e^{0.00672t}$; 42.8 million

China: $y = 1359.5e^{0.00115t}$; 1421.9 million

United Kingdom: $y = 60.4e^{0.00419t}$; 71.1 million

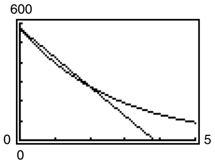
United States: $y = 291.1e^{0.00665t}$; 377.3 million

(b) b; The greater the rate of growth, the greater the value of b.

29. About 800 bacteria

31. (a) $V = -150t + 575$ (b) $V = 575e^{-0.3688t}$

(c)



The exponential model depreciates faster.

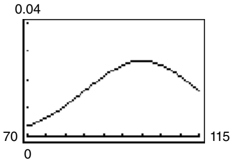
(d) Linear model: \$425; \$125

Exponential model: \$397.65; \$190.18

(e) Answers will vary.

33. About 12,180 yr old

35.



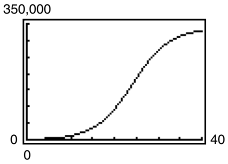
100

37. (a) 1998: 64,770 sites

2008: 240,797 sites

2015: 312,340 sites

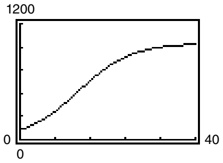
(b)



(c) and (d) 2007

39. (a) 203 animals (b) 13 mo

(c)



Horizontal asymptotes: $p = 0, p = 1000$. The population size will approach 1000 as time increases.

41. (a) 20 dB (b) 70 dB (c) 40 dB (d) 90 dB

43. 95%

45. (a) $10^{7.6} \approx 39{,}810{,}717$ (b) $10^{5.6} \approx 398{,}107$

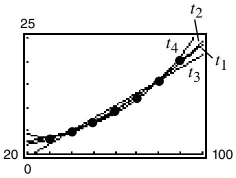
(c) $10^{6.6} \approx 3{,}981{,}072$

47. 4.64 **49.** 1.58×10^{-6} moles/L

51. $10^{5.1}$ **53.** 3:00 A.M.

55. (a) $t_3 = 0.2729s - 6.0143$

$t_4 = 1.5385e^{0.02913s}$ or $t_4 = 1.5385(1.0296)^s$



(b)

s	30	40	50	60	70	80	90
t_1	3.6	4.6	6.7	9.4	12.5	15.9	19.6
t_2	3.3	4.9	7.0	9.5	12.5	15.9	19.9
t_3	2.2	4.9	7.6	10.4	13.1	15.8	18.5
t_4	3.7	4.9	6.6	8.8	11.8	15.8	21.2

(c) Model t_1: Sum = 2.0, Model t_2: Sum = 1.1

Model t_3: Sum = 5.6, Model t_4: Sum = 2.7

The quadratic model (t_2) fits best.

57. False. The domain can be the set of real numbers for a logistic growth function.

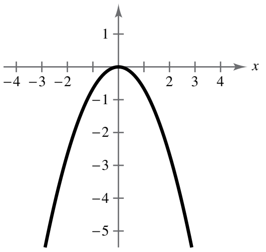
59. True. The graph of a Gaussian model will never have a zero.

61. Gaussian **63.** Exponential growth

65. $\dfrac{x^2 + 4x - 9}{(x - 3)(x + 1)}$ **67.** $\dfrac{x - 1}{2}, x \neq -1, 0$

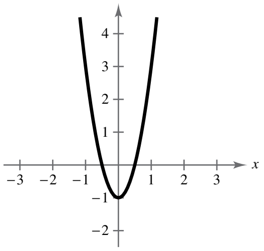
69. Quadrant III **71.** Quadrant IV

73.



Reflection in the x-axis and a vertical shrink

75.



Vertical shift one unit downward and a horizontal shrink

77. All real numbers x

79. All real numbers x such that $x \neq 0$ and $x \neq -3$

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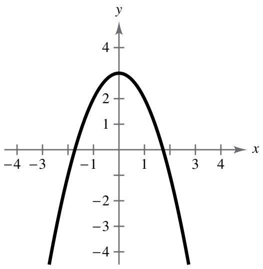
81.

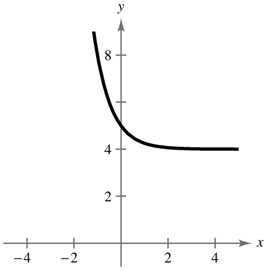


Review Exercises *(page 250)*

1. 0.164 **3.** 1.587 **5.** 1456.529

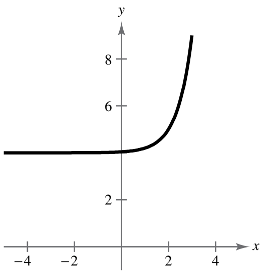
7.

x	-1	0	1	2	3
$f(x)$	8	5	4.25	4.063	4.016



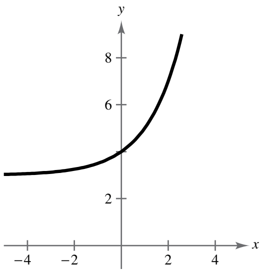
9.

x	-1	0	1	2	3
$f(x)$	4.008	4.04	4.2	5	9



11.

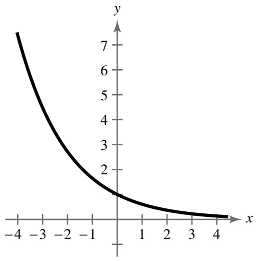
x	-2	-1	0	1	2
$f(x)$	3.25	3.5	4	5	7



13. 1 **15.** 4 **17.** Shift the graph of f one unit up.
19. Reflect f in the x-axis and shift one unit up.
21. 29.964 **23.** 1.822

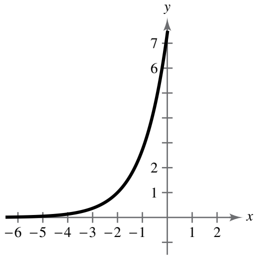
25.

x	-2	-1	0	1	2
$h(x)$	2.72	1.65	1	0.61	0.37



27.

x	-3	-2	-1	0	1
$f(x)$	0.37	1	2.72	7.39	20.09



29. (a) 0.283 (b) 0.487 (c) 0.811

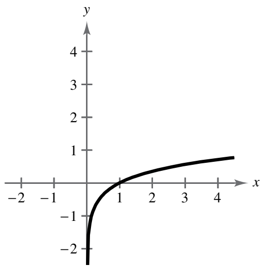
31.

n	1	2	4	12
A	\$6719.58	\$6734.28	\$6741.74	\$6746.77

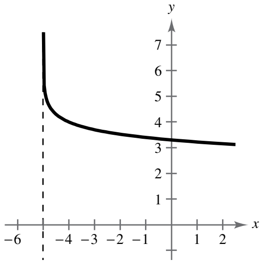
n	365	Continuous
A	\$6749.21	\$6749.29

33. $\log_3 27 = 3$ **35.** $\ln 2.2255\ldots = 0.8$
37. 3 **39.** -2 **41.** 7 **43.** -5

45. Domain: $(0, \infty)$
x-intercept: $(1, 0)$
Vertical asymptote: $x = 0$



47. Domain: $(-5, \infty)$
x-intercept: $(9995, 0)$
Vertical asymptote: $x = -5$



49. 3.118 **51.** 0.25

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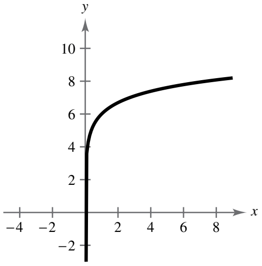
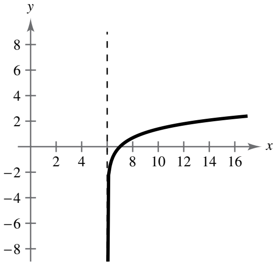
53. Domain: $(0, \infty)$
x-intercept: $(e^{-6}, 0)$
Vertical asymptote: $x = 0$



55. Domain: $(6, \infty)$
x-intercept: $(7, 0)$
Vertical asymptote: $x = 6$



57. About 14.32 parsecs **59.** (a) and (b) 2.585

61. (a) and (b) -2.322 **63.** $\log_2 5 - \log_2 3$

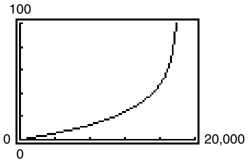
65. $2 \log_2 3 - \log_2 5$ **67.** $\log 7 + 2 \log x$

69. $2 - \frac{1}{2}\log_3 x$ **71.** $2 \ln x + 2 \ln y + \ln z$

73. $\ln 7x$ **75.** $\log \dfrac{x}{\sqrt{y}}$ **77.** $\log_3 \dfrac{\sqrt{x}}{(y + 8)^2}$

79. (a) $0 \le h < 18{,}000$

(b)



Vertical asymptote: $h = 18{,}000$

(c) The plane is climbing at a slower rate, so the time required increases.

(d) 5.46 min

81. 3 **83.** $\ln 3 \approx 1.099$ **85.** $e^4 \approx 54.598$

87. 1, 3 **89.** $\dfrac{\ln 32}{\ln 2} = 5$ **91.** $\frac{1}{3}e^{8.2} \approx 1213.650$

93. $\dfrac{3}{2} + \dfrac{\sqrt{9 + 4e}}{2} \approx 3.729$ **95.** No solution

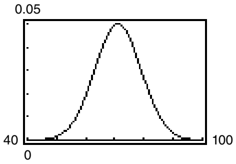
97. 0.900 **99.** 2.447 **101.** 9.182

103. 73.2 yr **105.** e **106.** b **107.** f

108. d **109.** a **110.** c

111. $y = 2e^{0.1014x}$

113.



71

115. (a) 10^{-6} W/m² (b) $10\sqrt{10}$ W/m²

(c) 1.259×10^{-12} W/m²

117. True by the inverse properties.

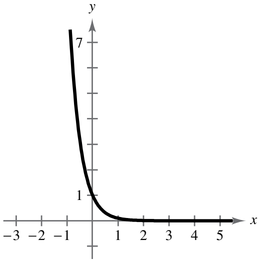
119. Answers will vary.

Chapter Test *(page 253)*

1. 0.410 **2.** 0.032 **3.** 0.497 **4.** 22.198

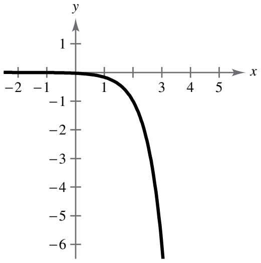
5.

x	-1	$-\frac{1}{2}$	0	$\frac{1}{2}$	1
$f(x)$	10	3.162	1	0.316	0.1



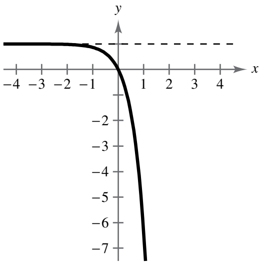
6.

x	-1	0	1	2	3
$f(x)$	-0.005	-0.028	-0.167	-1	-6



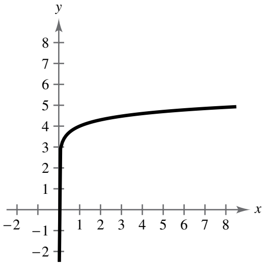
7.

x	-1	$-\frac{1}{2}$	0	$\frac{1}{2}$	1
$f(x)$	0.865	0.632	0	-1.718	-6.389

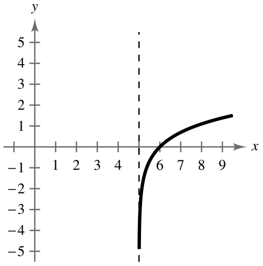


8. (a) -0.89 (b) 9.2

9. Domain: $(0, \infty)$
x-intercept: $(10^{-4}, 0)$
Vertical asymptote: $x = 0$



10. Domain: $(5, \infty)$
x-intercept: $(6, 0)$
Vertical asymptote: $x = 5$



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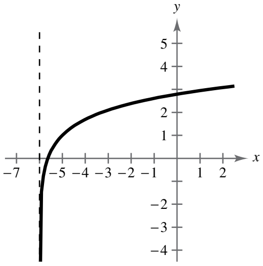
11. Domain: $(-6, \infty)$
x-intercept: $(e^{-1} - 6, 0)$
Vertical asymptote: $x = -6$



12. 2.209 **13.** -0.167 **14.** -11.047

15. $\log_2 3 + 4 \log_2 a$ **16.** $\frac{1}{2} \ln x - \ln 7$

17. $1 + 2 \log x - 3 \log y$ **18.** $\log_3 13y$ **19.** $\ln \frac{x^4}{y^4}$

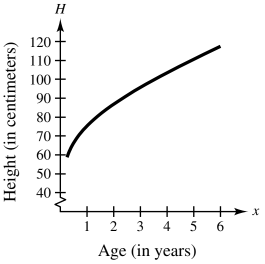
20. $\ln \frac{x^3y^2}{x + 3}$ **21.** $1, -1$ **22.** $\frac{\ln 44}{-5} \approx -0.757$

23. $\frac{\ln 197}{4} \approx 1.321$ **24.** $e^{-1/2} \approx 0.607$ **25.** $e^{-11/4} \approx 0.064$

26. 1 **27.** $y = 2745e^{0.1570t}$ **28.** 55%

29. (a)

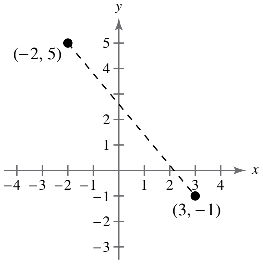
x	$\frac{1}{4}$	1	2	4	5	6
H	58.720	75.332	86.828	103.43	110.59	117.38



(b) 103 cm; 103.43 cm

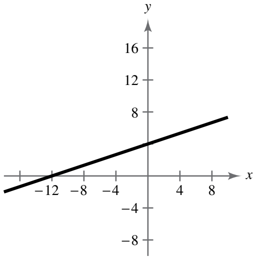
Cumulative Test for Chapters 1–3 *(page 254)*

1.

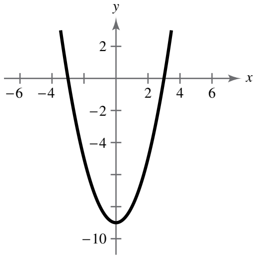


Midpoint: $\left(\frac{1}{2}, 2\right)$
Distance: $\sqrt{61}$

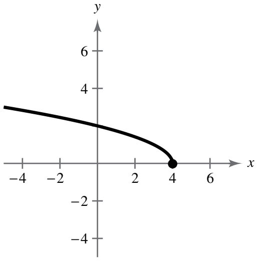
2.



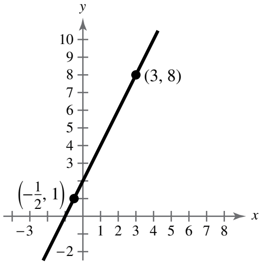
3.



4.



5. $y = 2x + 2$



6. (a) $\frac{3}{2}$ (b) Division by 0 is undefined. (c) $\frac{s + 2}{s}$

7. For some values of x there correspond two values of y.

8. (a) Vertical shrink (b) Upward shift of two units
(c) Left shift of two units

9. (a) $4x - 3$ (b) $-2x - 5$ (c) $3x^2 - 11x - 4$
(d) $\frac{x - 4}{3x + 1}$; Domain: all real numbers x except $x = -\frac{1}{3}$

10. (a) $\sqrt{x - 1} + x^2 + 1$ (b) $\sqrt{x - 1} - x^2 - 1$
(c) $x^2\sqrt{x - 1} + \sqrt{x - 1}$
(d) $\frac{\sqrt{x - 1}}{x^2 + 1}$; Domain: all real numbers x such that $x \geq 1$

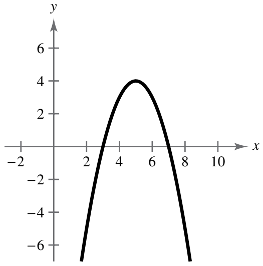
11. (a) $2x + 12$ (b) $\sqrt{2x^2 + 6}$
Domain of f: all real numbers x
Domain of g: all real numbers x such that $x \geq -6$
Domain of $f \circ g$: all real numbers x such that $x \geq -6$
Domain of $g \circ f$: all real numbers x

12. (a) $|x| - 2$ (b) $|x - 2|$
Domains of f, g, $f \circ g$ and $g \circ f$: all real numbers x

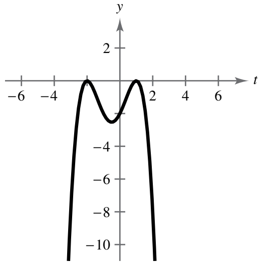
13. $h(x)^{-1} = \frac{1}{3}(x + 4)$ **14.** 2438.64 kW

15. $y = -\frac{3}{4}(x + 8)^2 + 5$

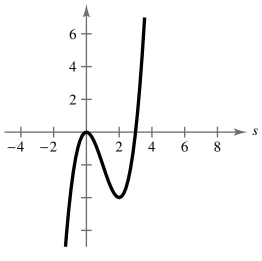
16.



17.



18.



19. $-2, \pm 2i$ **20.** $-7, 0, 3$ **21.** $4, -\frac{1}{2}, 1 \pm 3i$

22. $3x - 2 - \frac{3x - 2}{2x^2 + 1}$ **23.** $3x^3 + 6x^2 + 14x + 23 + \frac{49}{x - 2}$

24. $[1, 2]$; 1.196

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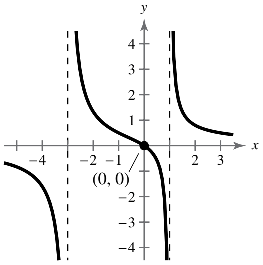
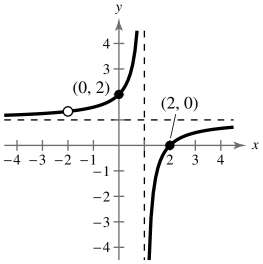
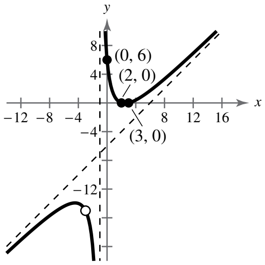
25. Intercept: $(0, 0)$
Vertical asymptotes: $x = 1, x = -3$
Horizontal asymptote: $y = 0$



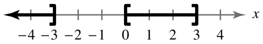
26. y-intercept: $(0, 2)$
x-intercept: $(2, 0)$
Vertical asymptote: $x = 1$
Horizontal asymptote: $y = 1$



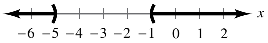
27. y-intercept: $(0, 6)$
x-intercepts: $(2, 0), (3, 0)$
Vertical asymptote: $x = -1$
Slant asymptote: $y = x - 6$



28. $x \le -3$ or $0 \le x \le 3$



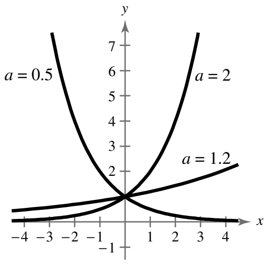
29. All real numbers x such that $x < -5$ or $x > -1$



30. Reflect f in the x-axis and y-axis, and shift three units to the right.
31. Reflect f in the x-axis and shift four units up.
32. 1.991 **33.** -0.067 **34.** 1.717 **35.** 0.390
36. $\ln(x + 5) + \ln(x - 5) - 4 \ln x$
37. $\ln \dfrac{x^2}{\sqrt{x + 5}}, \ x > 0$ **38.** $\dfrac{\ln 12}{2} \approx 1.242$
39. $\ln 6 \approx 1.792$ or $\ln 7 \approx 1.946$
40. $e^6 - 2 \approx 401.429$ **41.** \$16,302.05
42. 6.3 h **43.** 2027

Problem Solving *(page 257)*

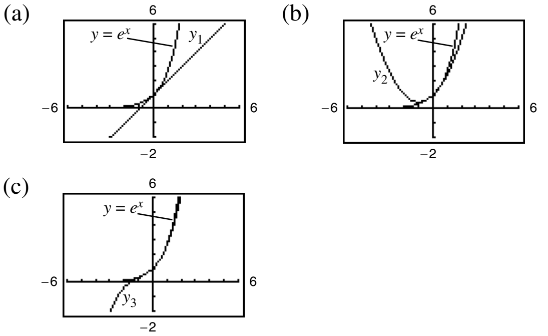
1.



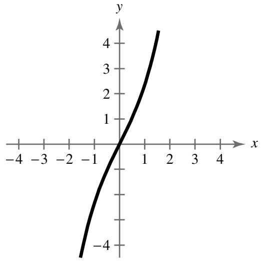
$y = 0.5^x$ and $y = 1.2^x$
$0 < a \le e^{1/e}$

3. As $x \to \infty$, the graph of e^x increases at a greater rate than the graph of x^n.
5. Answers will vary.

7.



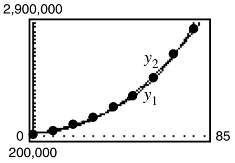
9.



$$f^{-1}(x) = \ln\left(\frac{x + \sqrt{x^2 + 4}}{2}\right)$$

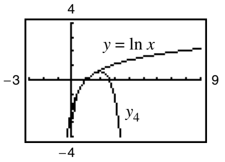
11. c **13.** $t = \dfrac{\ln c_1 - \ln c_2}{\left(\dfrac{1}{k_2} - \dfrac{1}{k_1}\right)\ln \dfrac{1}{2}}$

15. (a) $y_1 = 252{,}606(1.0310)^t$
(b) $y_2 = 400.88t^2 - 1464.6t + 291{,}782$
(c)



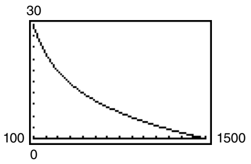
(d) The exponential model is a better fit. No, because the model is rapidly approaching infinity.

17. $1, e^2$
19. $y_4 = (x - 1) - \frac{1}{2}(x - 1)^2 + \frac{1}{3}(x - 1)^3 - \frac{1}{4}(x - 1)^4$



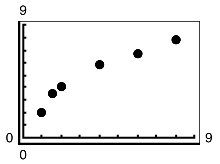
The pattern implies that
$\ln x = (x - 1) - \frac{1}{2}(x - 1)^2 + \frac{1}{3}(x - 1)^3 - \cdots.$

21.



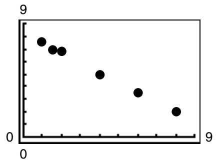
17.7 ft^3/min

23. (a)



(b)–(e) Answers will vary.

25. (a)



(b)–(e) Answers will vary.

Chapter 4

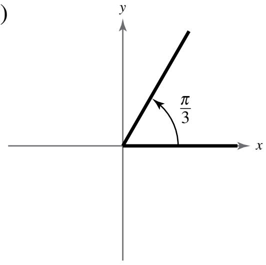
Section 4.1 *(page 267)*

1. coterminal **3.** linear; angular

5. $\frac{\pi}{2}$ radians; π radians **7.** 1 rad **9.** -3 rad

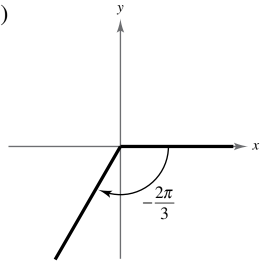
11. (a) Quadrant I (b) Quadrant II

13. (a)



No; Quadrant I

(b)



No; Quadrant III

15. *Sample answers:* (a) $\frac{13\pi}{6}, -\frac{11\pi}{6}$ (b) $\frac{7\pi}{6}, -\frac{17\pi}{6}$

17. (a) Complement: $\frac{5\pi}{12}$; Supplement: $\frac{11\pi}{12}$

(b) Complement: none; Supplement: $\frac{\pi}{12}$

19. (a) Complement: $\frac{\pi}{2} - 1 \approx 0.57$;

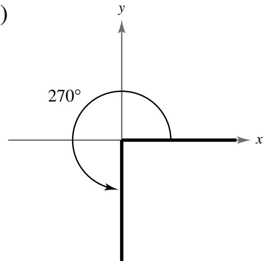
Supplement: $\pi - 1 \approx 2.14$

(b) Complement: none; Supplement: $\pi - 2 \approx 1.14$

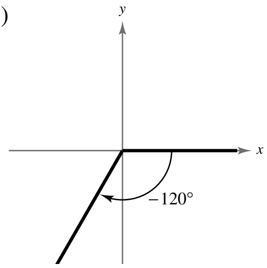
21. 210° **23.** $-60°$

25. (a) Quadrant II (b) Quadrant IV

27. (a)



(b)



29. (a) 480°, $-240°$ (b) 150°, $-570°$

31. (a) Complement: 72°; Supplement: 162°

(b) Complement: 5°; Supplement: 95°

33. (a) Complement: 66°; Supplement: 156°

(b) Complement: none; Supplement: 54°

35. (a) $\frac{2\pi}{3}$ (b) $-\frac{\pi}{9}$ **37.** (a) 270° (b) $-210°$

39. 0.785 **41.** -0.009 **43.** 81.818° **45.** $-756.000°$

47. (a) 54.75° (b) $-128.5°$

49. (a) 240° 36′ (b) $-145°$ 48′

51. 10π in. ≈ 31.42 in. **53.** $\frac{15}{8}$ rad **55.** 4 rad

57. About 18.85 in.^{2}

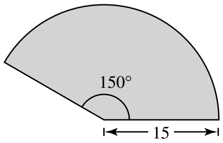
59. 20° should be multiplied by $\frac{\pi \text{ rad}}{180 \text{ deg}}$.

61. About 592 mi **63.** About 23.87°

65. (a) 8π rad/min ≈ 25.13 rad/min

(b) 200π ft/min ≈ 628.3 ft/min

67.



$A = 93.75\pi \text{ m}^2 \approx 294.52 \text{ m}^2$

69. False. $\frac{180°}{\pi}$ is in degree measure.

71. True. Let α and β represent coterminal angles, and let n represent an integer.

$\alpha = \beta + n(360°)$

$\alpha - \beta = n(360°)$

73. Proof

75. 25 **77.** 12 **79.** $\frac{40}{17} - \frac{10}{17}i$ **81.** $\frac{8}{25} + \frac{6}{25}i$

Section 4.2 *(page 275)*

1. unit circle **3.** odd; even

5. $\sin t = \frac{5}{13}$ $\csc t = \frac{13}{5}$

$\cos t = \frac{12}{13}$ $\sec t = \frac{13}{12}$

$\tan t = \frac{5}{12}$ $\cot t = \frac{12}{5}$

7. $\sin t = -\frac{3}{5}$ $\csc t = -\frac{5}{3}$

$\cos t = -\frac{4}{5}$ $\sec t = -\frac{5}{4}$

$\tan t = \frac{3}{4}$ $\cot t = \frac{4}{3}$

9. (0, 1) **11.** $\left(-\frac{\sqrt{3}}{2}, \frac{1}{2}\right)$

13. $\sin \frac{\pi}{4} = \frac{\sqrt{2}}{2}$

$\cos \frac{\pi}{4} = \frac{\sqrt{2}}{2}$

$\tan \frac{\pi}{4} = 1$

15. $\sin\left(-\frac{\pi}{6}\right) = -\frac{1}{2}$

$\cos\left(-\frac{\pi}{6}\right) = \frac{\sqrt{3}}{2}$

$\tan\left(-\frac{\pi}{6}\right) = -\frac{\sqrt{3}}{3}$

17. $\sin\left(-\frac{7\pi}{4}\right) = \frac{\sqrt{2}}{2}$

$\cos\left(-\frac{7\pi}{4}\right) = \frac{\sqrt{2}}{2}$

$\tan\left(-\frac{7\pi}{4}\right) = 1$

19. $\sin \frac{11\pi}{6} = -\frac{1}{2}$

$\cos \frac{11\pi}{6} = \frac{\sqrt{3}}{2}$

$\tan \frac{11\pi}{6} = -\frac{\sqrt{3}}{3}$

21. $\sin\left(-\frac{3\pi}{2}\right) = 1$

$\cos\left(-\frac{3\pi}{2}\right) = 0$

$\tan\left(-\frac{3\pi}{2}\right)$ is undefined.

23. $\sin \frac{2\pi}{3} = \frac{\sqrt{3}}{2}$ $\csc \frac{2\pi}{3} = \frac{2\sqrt{3}}{3}$

$\cos \frac{2\pi}{3} = -\frac{1}{2}$ $\sec \frac{2\pi}{3} = -2$

$\tan \frac{2\pi}{3} = -\sqrt{3}$ $\cot \frac{2\pi}{3} = -\frac{\sqrt{3}}{3}$

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25. $\sin\frac{4\pi}{3} = -\frac{\sqrt{3}}{2}$ $\csc\frac{4\pi}{3} = -\frac{2\sqrt{3}}{3}$

$\cos\frac{4\pi}{3} = -\frac{1}{2}$ $\sec\frac{4\pi}{3} = -2$

$\tan\frac{4\pi}{3} = \sqrt{3}$ $\cot\frac{4\pi}{3} = \frac{\sqrt{3}}{3}$

27. $\sin\left(-\frac{5\pi}{3}\right) = \frac{\sqrt{3}}{2}$ $\csc\left(-\frac{5\pi}{3}\right) = \frac{2\sqrt{3}}{3}$

$\cos\left(-\frac{5\pi}{3}\right) = \frac{1}{2}$ $\sec\left(-\frac{5\pi}{3}\right) = 2$

$\tan\left(-\frac{5\pi}{3}\right) = \sqrt{3}$ $\cot\left(-\frac{5\pi}{3}\right) = \frac{\sqrt{3}}{3}$

29. $\sin\left(-\frac{\pi}{2}\right) = -1$ $\csc\left(-\frac{\pi}{2}\right) = -1$

$\cos\left(-\frac{\pi}{2}\right) = 0$ $\sec\left(-\frac{\pi}{2}\right)$ is undefined.

$\tan\left(-\frac{\pi}{2}\right)$ is undefined. $\cot\left(-\frac{\pi}{2}\right) = 0$

31. 0 **33.** $\frac{1}{2}$ **35.** $-\frac{1}{2}$ **37.** (a) $-\frac{1}{2}$ (b) -2

39. (a) $-\frac{1}{5}$ (b) -5 **41.** (a) $\frac{4}{5}$ (b) $-\frac{4}{5}$

43. 0.5646 **45.** 0.4142 **47.** -1.0009

49. (a) 2 cm (b) About 0.14 cm

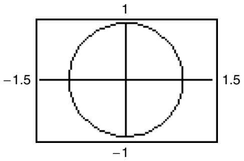
51. False. $\sin(-t) = -\sin(t)$ means that the function is odd, not that the sine of a negative angle is a negative number.

53. True. The tangent function has a period of π.

55. (a) y-axis symmetry (b) $\sin t_1 = \sin(\pi - t_1)$
(c) $\cos(\pi - t_1) = -\cos t_1$

57. The calculator was in degree mode instead of radian mode.

59. (a)



Circle of radius 1 centered at $(0, 0)$

(b) The t-values represent the central angle in radians. The x- and y-values represent the location in the coordinate plane.

(c) $-1 \le x \le 1, -1 \le y \le 1$

61. $(x - 17)^2 + (y - 7)^2 = 36$ **63.** $\left(x + \frac{7}{2}\right)^2 + (y + 6)^2 = \frac{5}{4}$

65. x-intercept: $(6, 0)$
y-intercepts: $(0, \pm\sqrt{6})$

67. x-intercepts: $\left(-\frac{1}{2}, 0\right), (2, 0)$
y-intercept: $(0, -4)$

Section 4.3 *(page 284)*

1. (a) 5 (b) 12 (c) 13 **3.** complementary

5. $\sin\theta = \frac{3}{5}$ $\csc\theta = \frac{5}{3}$

$\cos\theta = \frac{4}{5}$ $\sec\theta = \frac{5}{4}$

$\tan\theta = \frac{3}{4}$ $\cot\theta = \frac{4}{3}$

7. $\sin\theta = \frac{\sqrt{2}}{2}$ $\csc\theta = \sqrt{2}$

$\cos\theta = \frac{\sqrt{2}}{2}$ $\sec\theta = \sqrt{2}$

$\tan\theta = 1$ $\cot\theta = 1$

9. $\sin\theta = \frac{9}{41}$ $\csc\theta = \frac{41}{9}$

$\cos\theta = \frac{40}{41}$ $\sec\theta = \frac{41}{40}$

$\tan\theta = \frac{9}{40}$ $\cot\theta = \frac{40}{9}$

11. $\sin\theta = \frac{8}{17}$ $\csc\theta = \frac{17}{8}$

$\cos\theta = \frac{15}{17}$ $\sec\theta = \frac{17}{15}$

$\tan\theta = \frac{8}{15}$ $\cot\theta = \frac{15}{8}$

The triangles are similar, and corresponding sides are proportional.

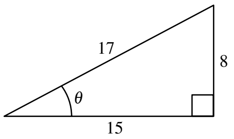
13. $\sin\theta = \frac{1}{3}$ $\csc\theta = 3$

$\cos\theta = \frac{2\sqrt{2}}{3}$ $\sec\theta = \frac{3\sqrt{2}}{4}$

$\tan\theta = \frac{\sqrt{2}}{4}$ $\cot\theta = 2\sqrt{2}$

The triangles are similar, and corresponding sides are proportional.

15.

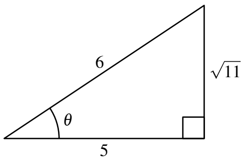


$\sin\theta = \frac{8}{17}$ $\csc\theta = \frac{17}{8}$

$\sec\theta = \frac{17}{15}$

$\tan\theta = \frac{8}{15}$ $\cot\theta = \frac{15}{8}$

17.

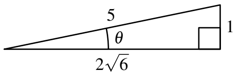


$\sin\theta = \frac{\sqrt{11}}{6}$ $\csc\theta = \frac{6\sqrt{11}}{11}$

$\cos\theta = \frac{5}{6}$

$\tan\theta = \frac{\sqrt{11}}{5}$ $\cot\theta = \frac{5\sqrt{11}}{11}$

19.

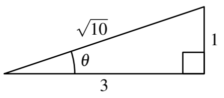


$\csc\theta = 5$

$\cos\theta = \frac{2\sqrt{6}}{5}$ $\sec\theta = \frac{5\sqrt{6}}{12}$

$\tan\theta = \frac{\sqrt{6}}{12}$ $\cot\theta = 2\sqrt{6}$

21.



$\sin\theta = \frac{\sqrt{10}}{10}$ $\csc\theta = \sqrt{10}$

$\cos\theta = \frac{3\sqrt{10}}{10}$ $\sec\theta = \frac{\sqrt{10}}{3}$

$\tan\theta = \frac{1}{3}$

23. $\frac{\pi}{6}; \frac{\sqrt{3}}{3}$ **25.** 45°; $\sqrt{2}$

27. (a) 0.3420 (b) 0.3420 **29.** (a) 0.2455 (b) 4.0737

31. (a) 0.9964 (b) 1.0036 **33.** (a) 3.2205 (b) 0.3105

35. (a) $\frac{1}{2}$ (b) $\frac{\sqrt{3}}{2}$ (c) $\sqrt{3}$ (d) $\frac{\sqrt{3}}{3}$

37. (a) $\frac{2\sqrt{2}}{3}$ (b) $2\sqrt{2}$ (c) 3 (d) 3

39. (a) $\frac{1}{3}$ (b) $\sqrt{10}$ (c) $\frac{1}{3}$ (d) $\frac{\sqrt{10}}{10}$

41–49. Answers will vary.

51. (a) $30° = \frac{\pi}{6}$ (b) $30° = \frac{\pi}{6}$

53. (a) $60° = \frac{\pi}{3}$ (b) $45° = \frac{\pi}{4}$

55. (a) $60° = \frac{\pi}{3}$ (b) $45° = \frac{\pi}{4}$ **57.** $x = 9, y = 9\sqrt{3}$

59. $x = \frac{32\sqrt{3}}{3}, r = \frac{64\sqrt{3}}{3}$

61. About 443.2 m; about 323.3 m

63. $30° = \frac{\pi}{6}$ **65.** (a) About 219.9 ft (b) About 160.9 ft

67. $(x_1, y_1) = (28\sqrt{3}, 28)$
$(x_2, y_2) = (28, 28\sqrt{3})$

69. $\sin 20° \approx 0.34$, $\cos 20° \approx 0.94$, $\tan 20° \approx 0.36$,
$\csc 20° \approx 2.92$, $\sec 20° \approx 1.06$, $\cot 20° \approx 2.75$

71. (a) About 519.33 ft
(b) About 1174.17 ft

73. True. $\csc x = \frac{1}{\sin x}$ **75.** False. $\frac{\sqrt{2}}{2} + \frac{\sqrt{2}}{2} \neq 1$

77. False. $1.7321 \neq 0.0349$

79. Yes, $\tan\theta$ is equal to opp/adj. You can find the value of the hypotenuse by the Pythagorean Theorem. Then you can find $\sec\theta$, which is equal to hyp/adj.

81. $\cos 60° = \frac{\text{adj}}{\text{hyp}} = \frac{1}{2}$

83. Quadrant I **85.** Quadrant II

87. Quadrants II and IV; *Sample answer:* $(1, -1), (-1, 1)$

89. Quadrants I and III; *Sample answer:* $(1, 2), (-1, -2)$

91. (a) 380°, −340° (b) 330°, −390°

93. Odd; origin symmetry **95.** Even; y-axis symmetry

Section 4.4 *(page 294)*

1. $\frac{y}{r}$ **3.** $\frac{y}{x}$ **5.** $\cos\theta$ **7.** Reference angle

9. (a) $\sin\theta = \frac{3}{5}$ $\csc\theta = \frac{5}{3}$
$\cos\theta = \frac{4}{5}$ $\sec\theta = \frac{5}{4}$
$\tan\theta = \frac{3}{4}$ $\cot\theta = \frac{4}{3}$
(b) $\sin\theta = \frac{15}{17}$ $\csc\theta = \frac{17}{15}$
$\cos\theta = -\frac{8}{17}$ $\sec\theta = -\frac{17}{8}$
$\tan\theta = -\frac{15}{8}$ $\cot\theta = -\frac{8}{15}$

11. (a) $\sin\theta = -\frac{1}{2}$ $\csc\theta = -2$
$\cos\theta = -\frac{\sqrt{3}}{2}$ $\sec\theta = -\frac{2\sqrt{3}}{3}$
$\tan\theta = \frac{\sqrt{3}}{3}$ $\cot\theta = \sqrt{3}$
(b) $\sin\theta = -\frac{\sqrt{17}}{17}$ $\csc\theta = -\sqrt{17}$
$\cos\theta = \frac{4\sqrt{17}}{17}$ $\sec\theta = \frac{\sqrt{17}}{4}$
$\tan\theta = -\frac{1}{4}$ $\cot\theta = -4$

13. $\sin\theta = \frac{12}{13}$ $\csc\theta = \frac{13}{12}$
$\cos\theta = \frac{5}{13}$ $\sec\theta = \frac{13}{5}$
$\tan\theta = \frac{12}{5}$ $\cot\theta = \frac{5}{12}$

15. $\sin\theta = -\frac{2\sqrt{29}}{29}$ $\csc\theta = -\frac{\sqrt{29}}{2}$
$\cos\theta = -\frac{5\sqrt{29}}{29}$ $\sec\theta = -\frac{\sqrt{29}}{5}$
$\tan\theta = \frac{2}{5}$ $\cot\theta = \frac{5}{2}$

17. $\sin\theta = \frac{4}{5}$ $\csc\theta = \frac{5}{4}$
$\cos\theta = -\frac{3}{5}$ $\sec\theta = -\frac{5}{3}$
$\tan\theta = -\frac{4}{3}$ $\cot\theta = -\frac{3}{4}$

19. Quadrant I **21.** Quadrant II

23. $\sin\theta = \frac{15}{17}$ $\csc\theta = \frac{17}{15}$
$\cos\theta = \frac{8}{17}$ $\sec\theta = \frac{17}{8}$
$\cot\theta = \frac{8}{15}$

25. $\csc\theta = \frac{5}{3}$
$\cos\theta = -\frac{4}{5}$ $\sec\theta = -\frac{5}{4}$
$\tan\theta = -\frac{3}{4}$ $\cot\theta = -\frac{4}{3}$

27. $\sin\theta = -\frac{\sqrt{10}}{10}$ $\csc\theta = -\sqrt{10}$
$\cos\theta = \frac{3\sqrt{10}}{10}$ $\sec\theta = \frac{\sqrt{10}}{3}$
$\tan\theta = -\frac{1}{3}$

29. $\sin\theta = 1$
$\sec\theta$ is undefined.
$\tan\theta$ is undefined. $\cot\theta = 0$

31. $\sin\theta = 0$ $\csc\theta$ is undefined.
$\cos\theta = -1$ $\sec\theta = -1$
$\tan\theta = 0$

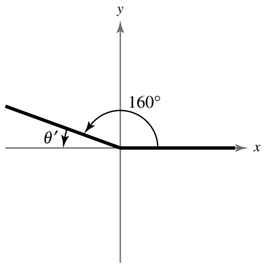
33. $\sin\theta = \frac{\sqrt{2}}{2}$ $\csc\theta = \sqrt{2}$
$\cos\theta = -\frac{\sqrt{2}}{2}$ $\sec\theta = -\sqrt{2}$
$\tan\theta = -1$ $\cot\theta = -1$

35. $\sin\theta = \frac{2\sqrt{5}}{5}$ $\csc\theta = \frac{\sqrt{5}}{2}$
$\cos\theta = \frac{\sqrt{5}}{5}$ $\sec\theta = \sqrt{5}$
$\tan\theta = 2$ $\cot\theta = \frac{1}{2}$

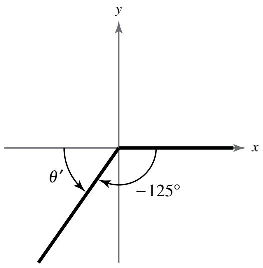
37. 0 **39.** Undefined **41.** 1

43. Undefined **45.** 0

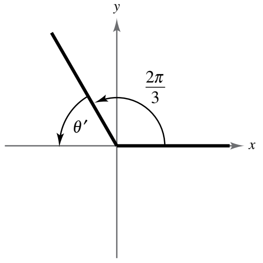
47. $\theta' = 20°$



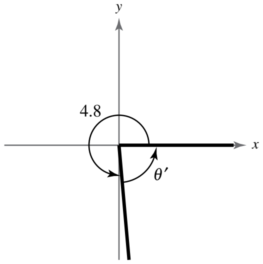
49. $\theta' = 55°$



51. $\theta' = \frac{\pi}{3}$



53. $\theta' = 2\pi - 4.8$



55. $\sin 225° = -\frac{\sqrt{2}}{2}$, $\cos 225° = -\frac{\sqrt{2}}{2}$, $\tan 225° = 1$

57. $\sin 750° = \frac{1}{2}$, $\cos 750° = \frac{\sqrt{3}}{2}$, $\tan 750° = \frac{\sqrt{3}}{3}$

59. $\sin(-120°) = -\frac{\sqrt{3}}{2}$, $\cos(-120°) = -\frac{1}{2}$, $\tan(-120°) = \sqrt{3}$

61. $\sin\frac{2\pi}{3} = \frac{\sqrt{3}}{2}$, $\cos\frac{2\pi}{3} = -\frac{1}{2}$, $\tan\frac{2\pi}{3} = -\sqrt{3}$

63. $\sin\left(-\frac{\pi}{6}\right) = -\frac{1}{2}$, $\cos\left(-\frac{\pi}{6}\right) = \frac{\sqrt{3}}{2}$, $\tan\left(-\frac{\pi}{6}\right) = -\frac{\sqrt{3}}{3}$

65. $\sin\frac{11\pi}{4} = \frac{\sqrt{2}}{2}$, $\cos\frac{11\pi}{4} = -\frac{\sqrt{2}}{2}$, $\tan\frac{11\pi}{4} = -1$

67. $\sin\left(-\frac{17\pi}{6}\right) = -\frac{1}{2}$, $\cos\left(-\frac{17\pi}{6}\right) = -\frac{\sqrt{3}}{2}$, $\tan\left(-\frac{17\pi}{6}\right) = \frac{\sqrt{3}}{3}$

69. $\frac{4}{5}$ **71.** $-\frac{\sqrt{13}}{12}$ **73.** $\frac{8\sqrt{39}}{39}$ **75.** 0.1736

77. -0.3420 **79.** -28.6363 **81.** 1.4142

83. 0.3640 **85.** -2.6131 **87.** -0.6052 **89.** 1.8382

91. (a) $30° = \frac{\pi}{6}, 150° = \frac{5\pi}{6}$ (b) $210° = \frac{7\pi}{6}, 330° = \frac{11\pi}{6}$

93. (a) $60° = \frac{\pi}{3}, 300° = \frac{5\pi}{3}$ (b) $60° = \frac{\pi}{3}, 300° = \frac{5\pi}{3}$

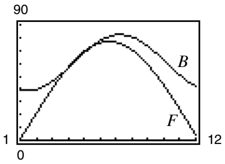
95. (a) $45° = \frac{\pi}{4}, 225° = \frac{5\pi}{4}$ (b) $150° = \frac{5\pi}{6}, 330° = \frac{11\pi}{6}$

97. (a) 12 mi (b) 6 mi (c) About 6.9 mi

99. (a) $B = 21.865\sin(0.540t - 2.343) + 60.438$
$F = 61.120\sin(0.325t - 0.561) + 15.787$

(b) February: $B \approx 39.6°, F \approx 21.2°$
April: $B \approx 56.5°, F \approx 57.0°$
May: $B \approx 68.1°, F \approx 69.2°$
July: $B \approx 82.1°, F \approx 76.3°$
September: $B \approx 73.2°, F \approx 58.7°$
October: $B \approx 62.3°, F \approx 42.5°$
December: $B \approx 42.1°, F \approx 3.8°$

(c)



Answers will vary.

101. False. In each of the four quadrants, the signs of the secant function and the cosine function are the same because these functions are reciprocals of each other.

103. Answers will vary.

105. (a) $f(x) = \sqrt{x}$
(b) Reflection in the x-axis, left shift of 12 units, and an upward shift of nine units

107. Relative maximum: $(-4, 5)$ **109.** $-12, 11$

Section 4.5 *(page 304)*

1. cycle **3.** Vertical shift of d units

5. Amplitude: 2; Period: $\frac{2\pi}{5}$

7. Amplitude: $\frac{3}{4}$; Period: 4

9. Amplitude: $\frac{1}{2}$; Period: $\frac{8\pi}{5}$

11. Amplitude: $\frac{5}{3}$; Period: 24

13. The period of g is one-fifth the period of f.

15. g is a reflection of f in the x-axis.

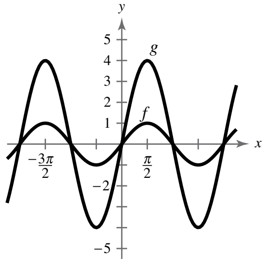
17. g is a shift of f π units to the right.

19. g is a shift of f three units up.

21. The graph of g has twice the amplitude of the graph of f.

23. The graph of g is a horizontal shift of the graph of f π units to the right.

25.



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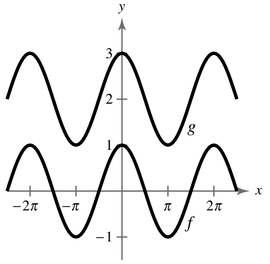

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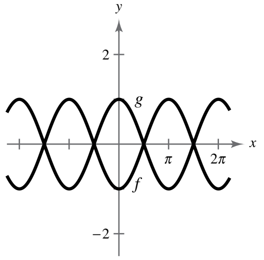

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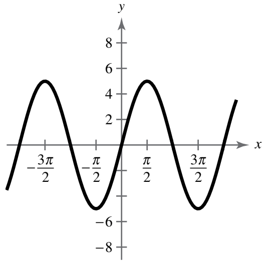

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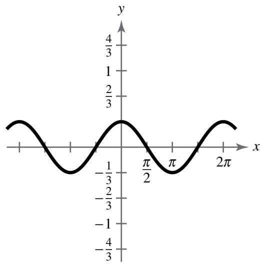

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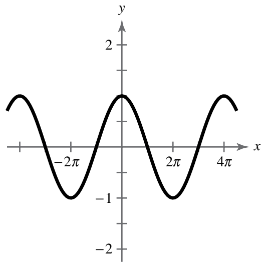

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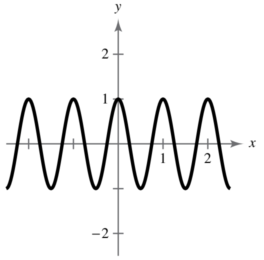

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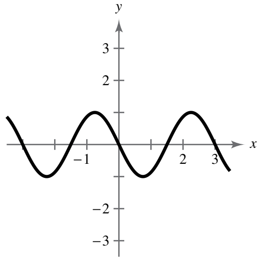

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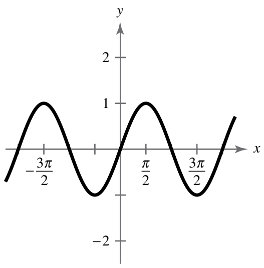

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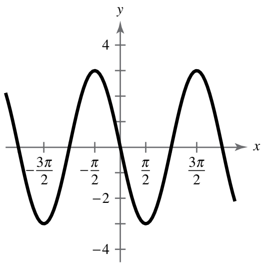

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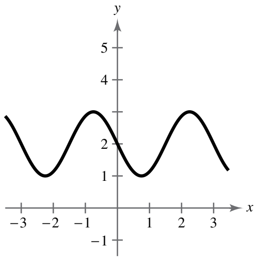

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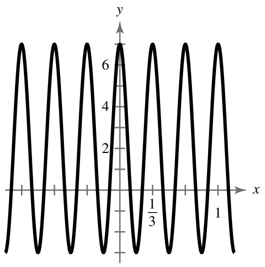

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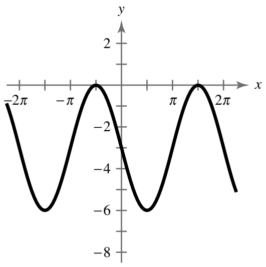

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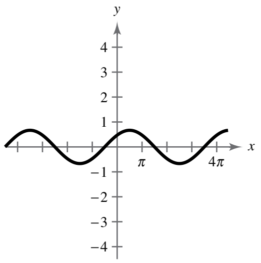
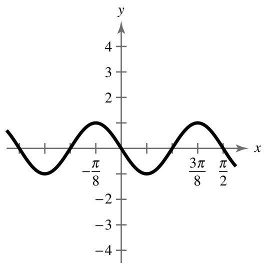


53. (a) Horizontal shrink and a phase shift $\pi/4$ unit right

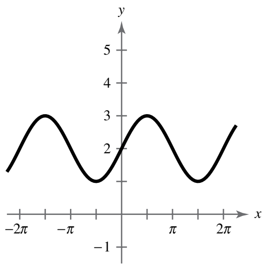
(b)



(c) $g(x) = f(4x - \pi)$

55. (a) Shift two units up and a phase shift $\pi/2$ units right

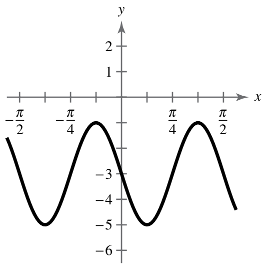
(b)



(c) $g(x) = f\left(x - \frac{\pi}{2}\right) + 2$

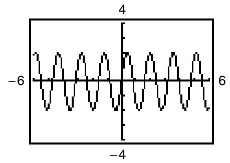
57. (a) Horizontal shrink, a vertical stretch, a shift three units down, and a phase shift $\pi/4$ unit right

(b)



(c) $g(x) = 2f(4x - \pi) - 3$

59.



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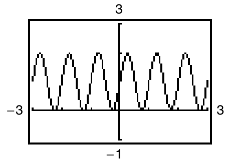

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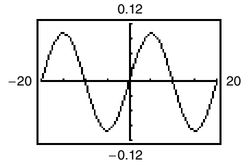
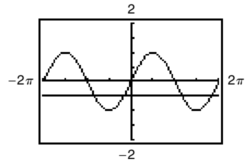


65. $a = 2, d = 1$ **67.** $a = -4, d = 4$

69. $a = -3, b = 2, c = 0$ **71.** $a = 2, b = 1, c = -\frac{\pi}{4}$

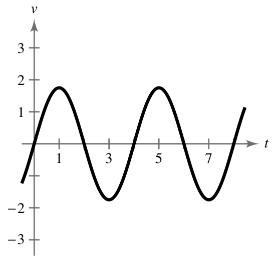
73.



$x = -\frac{\pi}{6}, -\frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$

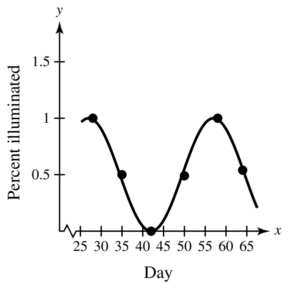
75. $y = 1 + 2\sin(2x - \pi)$ **77.** $y = \cos(2x + 2\pi) - \frac{3}{2}$

79. (a) 4 sec
(b) 15 cycles/min
(c)



81. (a) $\frac{6}{5}$ sec (b) 50 heartbeats/min

83. (a) and (c)



The model fits the data well.

(b) $y = 0.5\cos\left(\frac{\pi}{15}x - \frac{9\pi}{5}\right) + 0.5$

(d) 30 days (e) 100%

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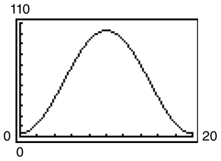
85. (a) 20 sec; It takes 20 seconds to complete one revolution on the Ferris wheel.

(b) 50 ft; The diameter of the Ferris wheel is 100 feet.

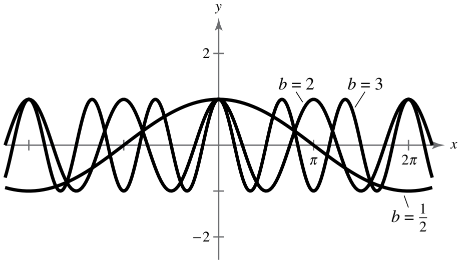
(c)



87. False. The function $y = \frac{1}{2}\cos 2x$ has an amplitude that is one-half that of $y = \cos x$. For $y = a\cos bx$, the amplitude is $|a|$.

89. The key points are for the graph of $y = \cos x$.

91.



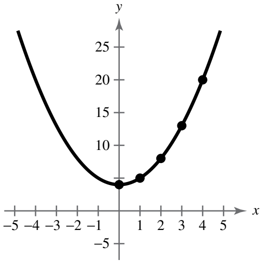
The value of b affects the period of the graph.
$b = \frac{1}{2} \to \frac{1}{2}$ cycle
$b = 2 \to 2$ cycles
$b = 3 \to 3$ cycles

93. (a)

x	0	1	2	3	4
y	4	5	8	13	20

(b) y-axis symmetry

(c)

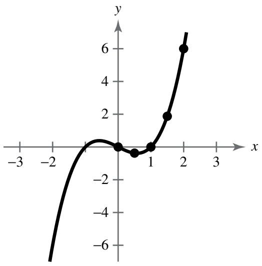


95. (a)

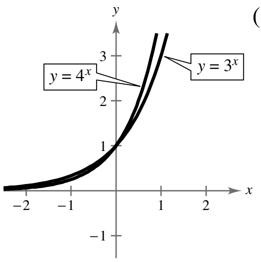
x	0	$\frac{1}{2}$	1	$\frac{3}{2}$	2
y	0	$-\frac{3}{8}$	0	$\frac{15}{8}$	6

(b) origin symmetry

(c)



97.

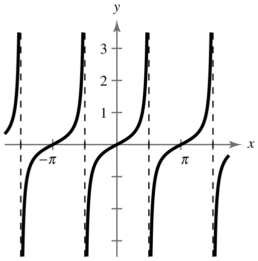


(a) $x < 0$ (b) $x > 0$

Section 4.6 *(page 315)*

1. odd; origin **3.** damping **5.** $(-\infty, -1] \cup [1, \infty)$
7. e, π **9.** a, 1 **11.** f, 4

13.



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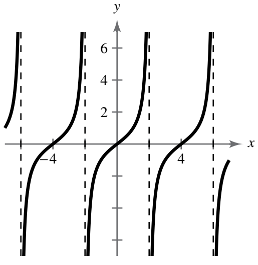

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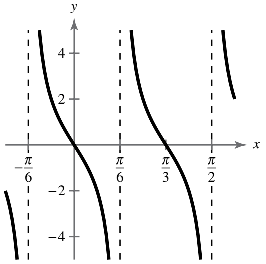

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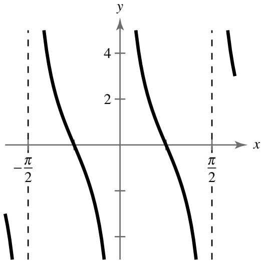

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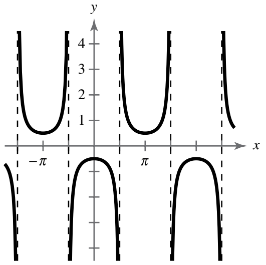

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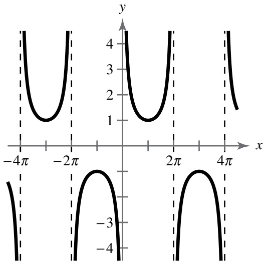

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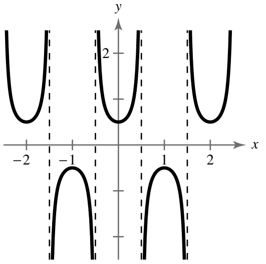

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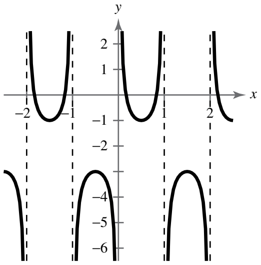

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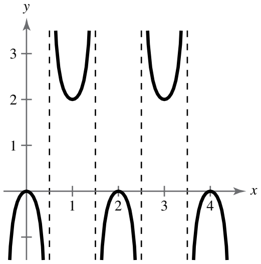

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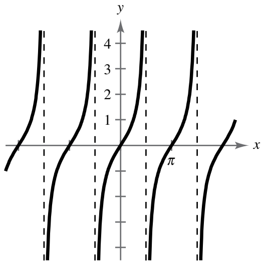

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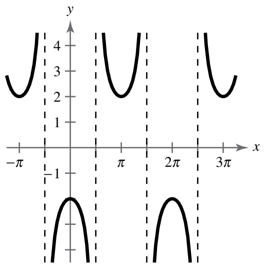

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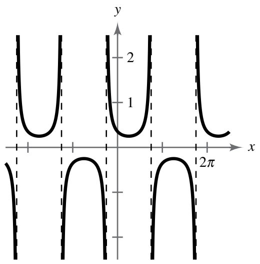

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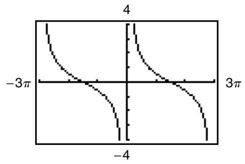

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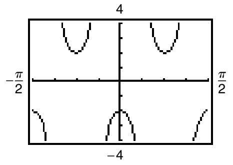

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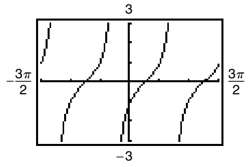

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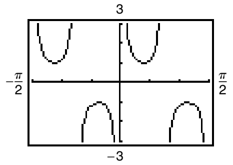

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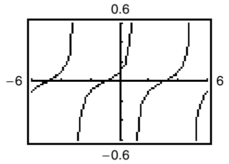


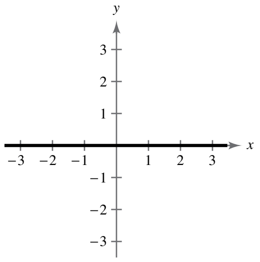
47. $-\frac{7\pi}{4}, -\frac{3\pi}{4}, \frac{\pi}{4}, \frac{5\pi}{4}$ **49.** $-\frac{7\pi}{6}, -\frac{\pi}{6}, \frac{5\pi}{6}, \frac{11\pi}{6}$

51. $-\frac{5\pi}{3}, -\frac{\pi}{3}, \frac{\pi}{3}, \frac{5\pi}{3}$

53. Even **55.** Odd **57.** Odd **59.** Even

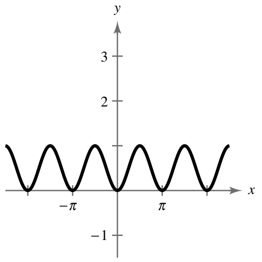
61. d, $f \to 0$ as $x \to 0$. **63.** b, $g \to 0$ as $x \to 0$.

65.



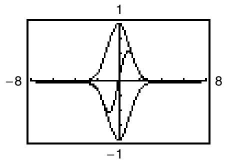
The functions are equal.

67.



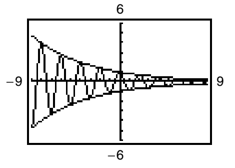
The functions are equal.

69.



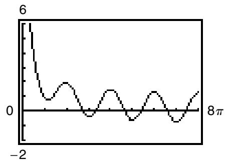
As $x \to \infty$, $g(x) \to 0$.

71.



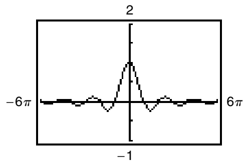
As $x \to \infty$, $f(x) \to 0$.

73.



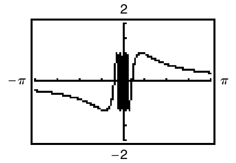
As $x \to 0$, $y \to \infty$.

75.



As $x \to 0$, $g(x) \to 1$.

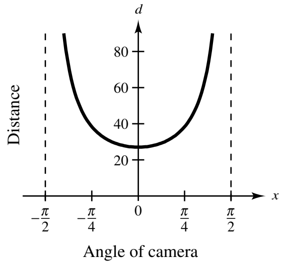
77.



As $x \to 0$, $f(x)$ oscillates between 1 and −1.

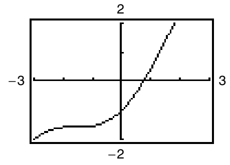
79. (a) Period of $H(t)$: 12 mo
Period of $L(t)$: 12 mo
(b) Summer; winter
(c) About 0.5 mo

81. $d = 27 \sec x$



83. True. For a given value of x, the y-coordinate of $\csc x$ is the reciprocal of the y-coordinate of $\sin x$.

85. (a)



0.7391

(b) 1, 0.5403, 0.8576, 0.6543, 0.7935, 0.7014, 0.7640, 0.7221, 0.7504, 0.7314, . . . ; 0.7391

87. (a) $x^{2/3}$ (b) $x^{2/3}$
Domains of f, g, $f \circ g$, and $g \circ f$: all real numbers x

89. (a) $(x-1)^2$ (b) $\sqrt{x^4 - 1}$
Domain of f: all real numbers x
Domains of g and $f \circ g$: all real numbers x such that $x \ge 1$
Domain of $g \circ f$: all real numbers x such that $x \le -1$ or $x \ge 1$

91. No inverse function **93.** $h^{-1}(x) = \frac{1}{\sqrt[3]{x}}$

95. $f^{-1}(x) = \frac{1}{3}(x^2 + 6),\ x \ge 0$ **97.** $\ln \frac{1}{2} \approx -0.693$

Section 4.7 *(page 324)*

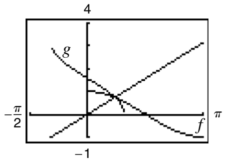
1. $y = \sin^{-1} x;\ -1 \le x \le 1$

3. $y = \tan^{-1} x;\ -\infty < x < \infty;\ -\frac{\pi}{2} < y < \frac{\pi}{2}$

5. $\csc^{-1} x$ or arccsc x **7.** $\frac{\pi}{6}$ **9.** $\frac{\pi}{2}$ **11.** $\frac{\pi}{6}$

13. Not possible **15.** $-\frac{\pi}{3}$ **17.** $\frac{2\pi}{3}$ **19.** $-\frac{\pi}{3}$

21.



23. 1.19 **25.** −0.85 **27.** −1.25 **29.** Not possible

31. Not possible **33.** −1.50 **35.** $-\frac{\pi}{3}, -\frac{\sqrt{3}}{3}, 1$

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37. $\theta = \arctan \frac{x}{4}$ **39.** $\theta = \arcsin \frac{x+2}{5}$

41. 0.3 **43.** $\frac{\pi}{4}$ **45.** $\frac{3}{5}$ **47.** $\frac{\sqrt{5}}{5}$

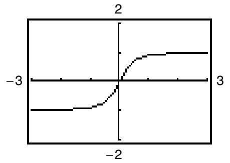
49. $\frac{13}{12}$ **51.** $-\frac{5}{3}$ **53.** $-\frac{\sqrt{5}}{2}$ **55.** 2

57. $\sqrt{1-4x^2}, 0 \le x \le \frac{1}{2}$ **59.** $\frac{1}{x}, x > 0$

61. $\sqrt{1-x^2}, 0 \le x \le 1$ **63.** $\frac{\sqrt{9-x^2}}{x}, 0 < x \le 0$

65. $\frac{\sqrt{x^2+a^2}}{x}, a \ge 0, x > 0$

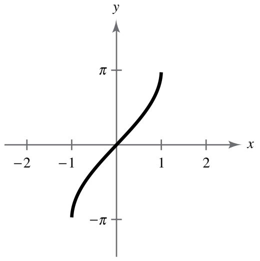
67.



Asymptotes: $y = \pm 1$

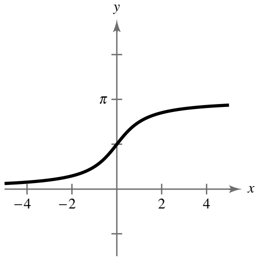
69. $\frac{9}{\sqrt{x^2+81}}$ **71.** $\frac{|x-1|}{\sqrt{x^2-2x+10}}$

73.



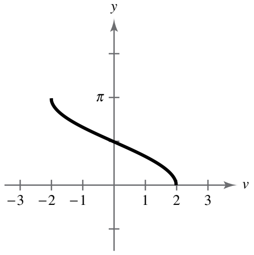
Vertical stretch

75.



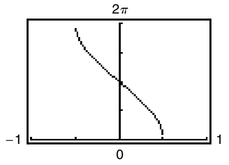
Shift $\frac{\pi}{2}$ units up

77.

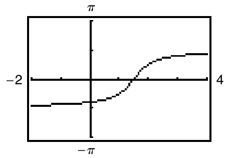


Horizontal stretch

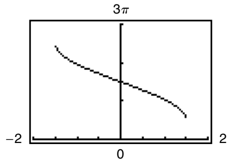
79.



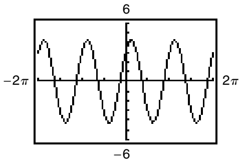
81.



83.



85. $3\sqrt{2}\sin\left(2t + \frac{\pi}{4}\right)$



The graph implies that the identity is true.

87. $\frac{\pi}{2}$ **89.** $\frac{\pi}{2}$ **91.** π

93. (a) $\theta = \arcsin \frac{5}{s}$ (b) About 0.13, about 0.25

95. (a) About 32.9° (b) About 6.5 m

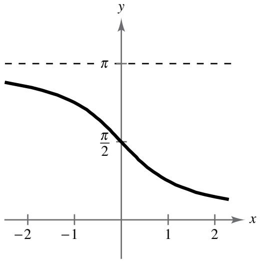
97. (a) $\theta = \arcsin \frac{6}{x}$ (b) 30°; about 59.0°

99. False. $\arctan(-1) = -\frac{\pi}{4} \ne \frac{\arcsin(-1)}{\arccos(-1)} = \frac{-\pi/2}{\pi} = -\frac{1}{2}$

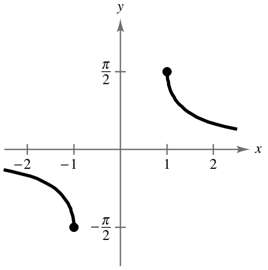
101. False. $\frac{5\pi}{6}$ is not in the range of the arcsine function.

103. $\frac{5\pi}{4}$ is not in the range of the arcsine function.

105. Domain: $(-\infty, \infty)$
Range: $(0, \pi)$



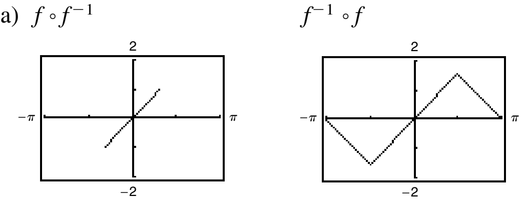
107. Domain: $(-\infty, -1] \cup [1, \infty)$
Range: $[-\pi/2, 0) \cup (0, \pi/2]$



109. $\frac{\pi}{4}$ **111.** $\frac{3\pi}{4}$ 113. $\frac{\pi}{6}$ **115.** $\frac{\pi}{3}$ **117.** $\frac{2\pi}{3}$

119. 1.17 **121.** −0.12 **123.** 0.19 **125.** 0.54

127. (a)



(b) The domains and ranges of the functions are restricted. The graphs of $f \circ f^{-1}$ and $f^{-1} \circ f$ differ because of the domains and ranges of f and f^{-1}.

129. (a) $\frac{\pi}{4}$ (b) $\frac{\pi}{2}$ (c) About 1.25 (d) About 2.03

131. $4\sqrt{5}$ **133.** $4\sqrt{2}$ **135.** $\cos 40° = \frac{c}{5}$

137. $\tan 40° = \frac{5}{c}$

Section 4.8 *(page 334)*

1. bearing **3.** No

5. $a \approx 10.39$
$b = 6$
$B = 30°$

7. $b \approx 14.21$
$c \approx 14.88$
$A = 17.2°$

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9. $c = 5$
$A \approx 36.87^\circ$
$B \approx 53.13^\circ$

11. $a \approx 52.88$
$A \approx 73.46^\circ$
$B \approx 16.54^\circ$

13. 3.00 **15.** 2.50 **17.** About 214.45 ft

19. About 19.7 ft **21.** About 20.5 ft **23.** About 11.8 km

25. (a) About 25.98 ft (b) $\arctan \dfrac{25.98}{d}$
(c) $45.0 \text{ ft} \le d \le 55.7 \text{ ft}$

27. About 56.3° **29.** About 75.97° **31.** N 56.31° W

33. (a) About 429.26 mi north, about 2434.44 mi west
(b) 280°

35. (a) About 4820.7 ft (b) About 124.5 sec

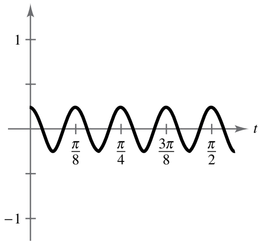
37. (a) N 58° E (b) About 68.82 m **39.** About 29.4 in.

41. About 35.3° **43.** $d = 4 \sin \pi t$ **45.** $d = 3 \cos \dfrac{4\pi t}{3}$

47. $\omega = 524\pi$ **49.** (a) 9 (b) $\frac{3}{5}$ (c) 9 (d) $\frac{5}{12}$

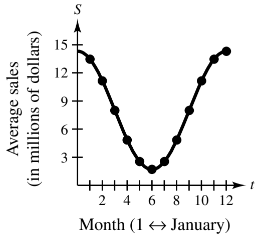
51. (a) $\frac{1}{4}$ (b) 3 (c) 0 (d) $\frac{1}{6}$

53. (a)



(b) $\dfrac{\pi}{8}$ (c) $\dfrac{\pi}{32}$

55. (a)



(b) $S = 8 + 6.3 \cos \dfrac{\pi}{6}t$ or $S = 8 + 6.3 \sin\left(\dfrac{\pi}{6}t + \dfrac{\pi}{2}\right)$
The model is a good fit.
(c) 12. Yes, sales of outerwear are seasonal.
(d) Maximum displacement from average sales of \$8 million

57. False. The scenario does not create a right triangle because the tower is not vertical.

59. $2t(3t^2 + 5t - 1)$ **61.** $(5y + 1)(2y - 3)$

63. $(5z^2 + x)(5z^2 - x)$

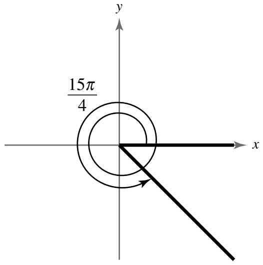
65. (a) $\dfrac{\sqrt{15}}{4}$ (b) $\sqrt{15}$ (c) 4 (d) $\sqrt{15}$

67. $\log_2 5x$ **69.** $\log \dfrac{x^3}{(x + 2)(x - 2)}$

Review Exercises *(page 340)*

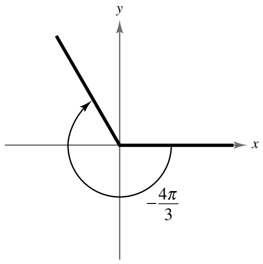
1. 2 rad **3.** 60°

5. (a)



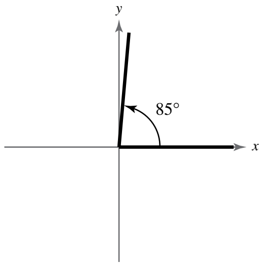
(b) Quadrant IV
(c) $\dfrac{7\pi}{4}, -\dfrac{\pi}{4}$

7. (a)



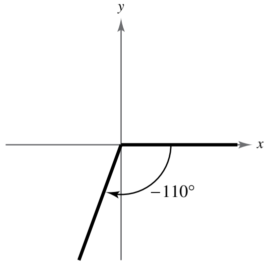
(b) Quadrant II
(c) $\dfrac{2\pi}{3}, -\dfrac{10\pi}{3}$

9. (a)



(b) Quadrant I
(c) 445°, −275°

11. (a)



(b) Quadrant III
(c) 250°, −470°

13. About 48.17 in. **15.** About 523.60 in.^{2}

17. $\left(-\dfrac{1}{2}, \dfrac{\sqrt{3}}{2}\right)$ **19.** $\left(-\dfrac{\sqrt{3}}{2}, -\dfrac{1}{2}\right)$

21. $\sin \dfrac{3\pi}{4} = \dfrac{\sqrt{2}}{2}$ $\csc \dfrac{3\pi}{4} = \sqrt{2}$
$\cos \dfrac{3\pi}{4} = -\dfrac{\sqrt{2}}{2}$ $\sec \dfrac{3\pi}{4} = -\sqrt{2}$
$\tan \dfrac{3\pi}{4} = -1$ $\cot \dfrac{3\pi}{4} = -1$

23. $\dfrac{\sqrt{2}}{2}$ **25.** $-\dfrac{\sqrt{3}}{2}$ **27.** 3.2361 **29.** −75.3130

31. $\sin \theta = \dfrac{4\sqrt{41}}{41}$ $\csc \theta = \dfrac{\sqrt{41}}{4}$
$\cos \theta = \dfrac{5\sqrt{41}}{41}$ $\sec \theta = \dfrac{\sqrt{41}}{5}$
$\tan \theta = \dfrac{4}{5}$ $\cot \theta = \dfrac{5}{4}$

33. 0.6494 **35.** 3.6722

37. (a) 3 (b) $\dfrac{2\sqrt{2}}{3}$ (c) $\dfrac{3\sqrt{2}}{4}$ (d) $\dfrac{\sqrt{2}}{4}$

39. About 73.3 m

41. $\sin \theta = \frac{4}{5}$ $\csc \theta = \frac{5}{4}$
$\cos \theta = \frac{3}{5}$ $\sec \theta = \frac{5}{3}$
$\tan \theta = \frac{4}{3}$ $\cot \theta = \frac{3}{4}$

43. $\sin \theta = \frac{4}{5}$ $\csc \theta = \frac{5}{4}$
$\cos \theta = \frac{3}{5}$ $\sec \theta = \frac{5}{3}$
$\tan \theta = \frac{4}{3}$ $\cot \theta = \frac{3}{4}$

45. $\sin \theta = -\dfrac{\sqrt{11}}{6}$ $\csc \theta = -\dfrac{6\sqrt{11}}{11}$
$\cos \theta = \dfrac{5}{6}$
$\tan \theta = -\dfrac{\sqrt{11}}{5}$ $\cot \theta = -\dfrac{5\sqrt{11}}{11}$

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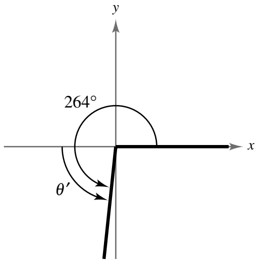
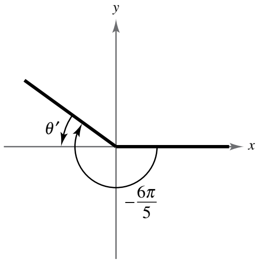
47. $\sin\theta = \dfrac{\sqrt{21}}{5}$ $\csc\theta = \dfrac{5\sqrt{21}}{21}$

$\sec\theta = -\dfrac{5}{2}$

$\tan\theta = -\dfrac{\sqrt{21}}{2}$ $\cot\theta = -\dfrac{2\sqrt{21}}{21}$

49. $\theta' = 84°$ **51.** $\theta' = \dfrac{\pi}{5}$



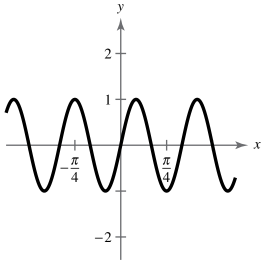


53. $\sin(-150°) = -\dfrac{1}{2}$; $\cos(-150°) = -\dfrac{\sqrt{3}}{2}$; $\tan(-150°) = \dfrac{\sqrt{3}}{3}$

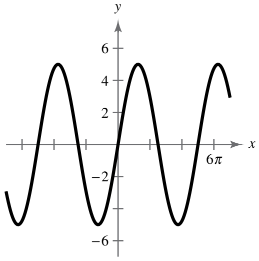
55. $\sin\dfrac{\pi}{3} = \dfrac{\sqrt{3}}{2}$; $\cos\dfrac{\pi}{3} = \dfrac{1}{2}$; $\tan\dfrac{\pi}{3} = \sqrt{3}$

57. 0.9613 **59.** −0.4452

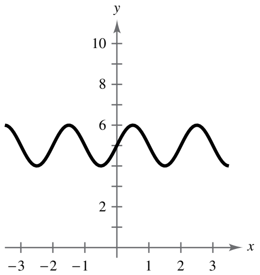
61.



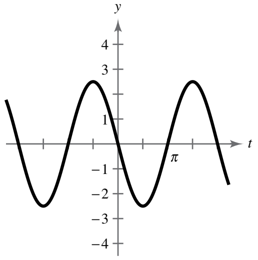
63.



65.



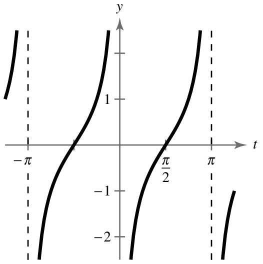
67.



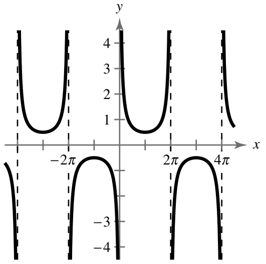
69. (a) $y = 2\sin 528\pi x$

(b) 264 cycles/sec

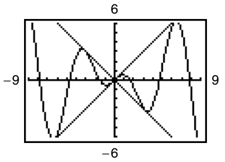
71.



73.



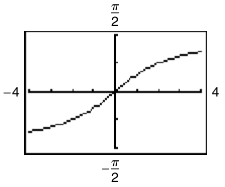
75.



As $x \to +\infty$, $f(x)$ oscillates.

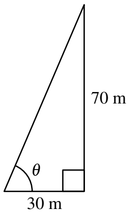
77. $-\dfrac{\pi}{2}$ **79.** $\dfrac{\pi}{6}$ **81.** −0.92 **83.** 0.06

85.



87. $\frac{4}{5}$ **89.** $\frac{13}{5}$ **91.** $\dfrac{\sqrt{4-x^2}}{x}$

93.



$\theta \approx 66.8°$

95. About 1221 mi, about 85.6°

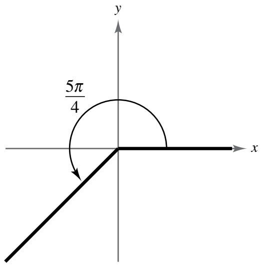
97. False. For each θ there corresponds exactly one value of y.

99. The function is undefined because $\sec\theta = 1/\cos\theta$.

101. The ranges of the other four trigonometric functions are $(-\infty, \infty)$ or $(-\infty, -1] \cup [1, \infty)$.

Chapter Test *(page 343)*

1. (a)



(b) $\dfrac{13\pi}{4}, -\dfrac{3\pi}{4}$ (c) 225°

2. 3500 rad/min **3.** About 709.04 ft^2

4. $\sin\dfrac{7\pi}{6} = -\dfrac{1}{2}$ $\cos\dfrac{7\pi}{6} = -\dfrac{\sqrt{3}}{2}$

$\tan\dfrac{7\pi}{6} = \dfrac{\sqrt{3}}{3}$

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5. $\sin\theta = \frac{3\sqrt{13}}{13}$ $\csc\theta = \frac{\sqrt{13}}{3}$
$\cos\theta = \frac{2\sqrt{13}}{13}$ $\sec\theta = \frac{\sqrt{13}}{2}$
$\cot\theta = \frac{2}{3}$

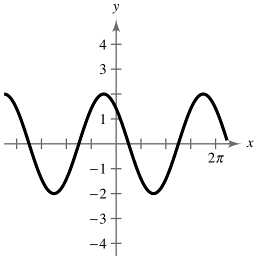
6. $\sin\theta = \frac{3\sqrt{10}}{10}$ $\csc\theta = \frac{\sqrt{10}}{3}$
$\cos\theta = -\frac{\sqrt{10}}{10}$ $\sec\theta = -\sqrt{10}$
$\tan\theta = -3$ $\cot\theta = -\frac{1}{3}$

7. Quadrant III **8.** 150°, 210°

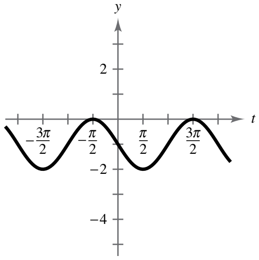
9. $\sin\theta = -\frac{4}{5}$
$\tan\theta = -\frac{4}{3}$
$\csc\theta = -\frac{5}{4}$
$\sec\theta = \frac{5}{3}$
$\cot\theta = -\frac{3}{4}$

10. $\sin\theta = \frac{21}{29}$
$\cos\theta = -\frac{20}{29}$
$\tan\theta = -\frac{21}{20}$
$\csc\theta = \frac{29}{21}$
$\cot\theta = -\frac{20}{21}$

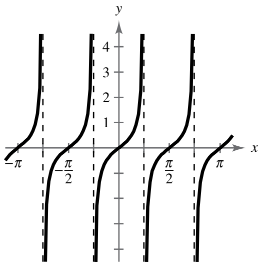
11.



12.

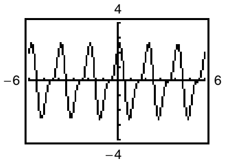


13.



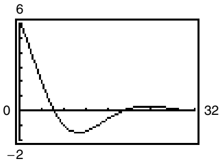
14. $a = -2, b = \frac{1}{2}, c = -\frac{\pi}{4}$

15.



Period: 2

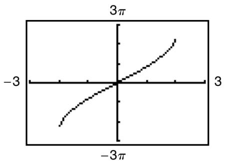
16.



Not periodic;
As $x \to \infty$, $y \to 0$.

17. $\frac{\sqrt{55}}{3}$

18.



19. About 309.3° **20.** $d = -6\cos\pi t$

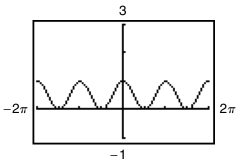
Problem Solving *(page 345)*

1. (a) $\frac{11\pi}{2}$ rad or 990° (b) About 816.42 ft

3. $h = 51 - 50\sin\left(8\pi t + \frac{\pi}{2}\right)$

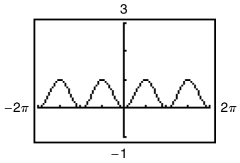
5. (a) About 4767 ft (b) About 3705 ft
(c) $w \approx 2183$ ft, $\tan 63° = \frac{w + 3705}{3000}$

7. (a)



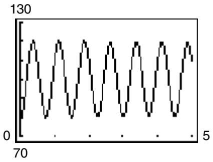
Even

(b)



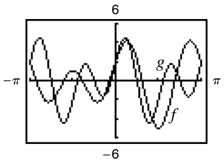
Even

9. (a)



(b) Period $= \frac{3}{4}$ sec; This is the time between heartbeats.
(c) 20 mm; The blood pressure ranges between 80 mm and 120 mm.
(d) 80 beats/min (e) Period $= \frac{15}{16}$ sec; $\frac{32\pi}{15}$

11. (a)



(b) Period of f: 2π
Period of g: π
(c) Yes, because the sine and cosine functions are periodic.

13. (a) About 40.5°
(b) $x \approx 1.71$ ft; $y \approx 3.46$ ft
(c) About 1.75 ft
(d) As you move closer to the rock, d must get smaller and smaller. The angles θ_1 and θ_2 will decrease along with the distance y, so d will decrease.

Chapter 5

Section 5.1 *(page 353)*

1. $\cot u$ **3.** $\csc^2 u$

5. $\sin x = \frac{\sqrt{21}}{5}$ $\csc x = \frac{5\sqrt{21}}{21}$
$\cos x = -\frac{2}{5}$ $\sec x = -\frac{5}{2}$
$\tan x = -\frac{\sqrt{21}}{2}$ $\cot x = -\frac{2\sqrt{21}}{21}$

7. $\sin\theta = -\frac{3}{4}$ $\csc\theta = -\frac{4}{3}$
$\cos\theta = \frac{\sqrt{7}}{4}$ $\sec\theta = \frac{4\sqrt{7}}{7}$
$\tan\theta = -\frac{3\sqrt{7}}{7}$ $\cot\theta = -\frac{\sqrt{7}}{3}$

9. $\sin x = \frac{2\sqrt{13}}{13}$ $\csc x = \frac{\sqrt{13}}{2}$
$\cos x = \frac{3\sqrt{13}}{13}$ $\sec x = \frac{\sqrt{13}}{3}$
$\tan x = \frac{2}{3}$ $\cot x = \frac{3}{2}$

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11. c **12.** b **13.** f **14.** a **15.** e **16.** d
17. $\cos\theta$ **19.** $\sin^2 x$ **21.** $\sec x + 1$ **23.** $\sin^4 x$
25. $\csc^2 x(\cot x + 1)$ **27.** $(3\sin x + 1)(\sin x - 2)$
29. $(\csc x - 1)(\csc x + 2)$ **31.** $\sec\theta$ **33.** $\cos^2\phi$
35. $\sec\beta$ **37.** $\sin^2 x$ **39.** $2\csc^2 x$ **41.** $-2\tan x$
43. $-\cot x$ **45.** $1 + \cos y$ **47.** $\sin x$ **49.** $0 \le \theta \le \pi$
51. $3\sin\theta$ **53.** $2\tan\theta$ **55.** $\ln|\cos x|$
57. $\ln|\csc t \sec t|$ **59.** $\mu = \tan\theta$ **61.** True. $\sin\theta = \dfrac{1}{\csc\theta}$
63. True. $\csc x = \dfrac{1}{\sin x}, \sec x = \dfrac{1}{\cos x}, \tan x = \dfrac{\sin x}{\cos x}, \cot x = \dfrac{\cos x}{\sin x}$

65. $\cos\theta = \pm\sqrt{1 - \sin^2\theta}$

$$\tan\theta = \pm\frac{\sin\theta}{\sqrt{1 - \sin^2\theta}}$$

$$\cot\theta = \pm\frac{\sqrt{1 - \sin^2\theta}}{\sin\theta}$$

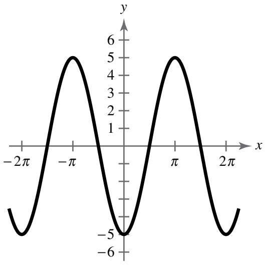
$$\sec\theta = \pm\frac{1}{\sqrt{1 - \sin^2\theta}}$$

$$\csc\theta = \frac{1}{\sin\theta}$$

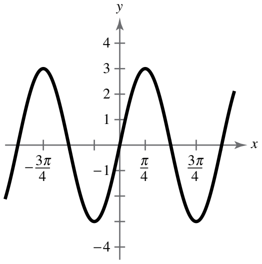
67. $a\sec\theta$ **69.** $\dfrac{x - 4}{2}, x \ne -4, 0$

71. $\dfrac{4}{(x - 1)^2}, x \ne -1, 0$ **73.** 58 **75.** 32

77.



79.

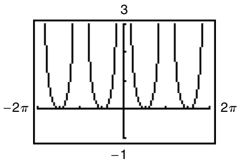


81. True. $\ln(xy) = \ln x + \ln y$

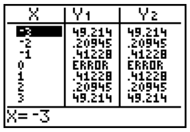
Section 5.2 *(page 360)*

1. identity
3. *Sample answer:* Actual equivalence of two expressions can only be verified algebraically.
5–41. Answers will vary.

43. (a)



(b)

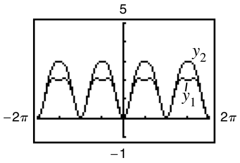


```
   X    |  Y1    |  Y2
 -3     | 49.214 | 49.214
 -2     | .20945 | .20945
 -1     | .41228 | .41228
 0      | ERROR  | ERROR
 1      | .41228 | .41228
 2      | .20945 | .20945
 3      | 49.214 | 49.214
X=-3
```

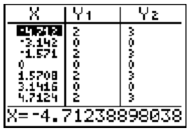
Identity

(c) Answers will vary.

45. (a)



(b)



```
   X    |  Y1  |  Y2
 -4.712 |  2   |  3
 -3.142 |  0   |  0
 -1.571 |  2   |  3
 0      |  0   |  0
 1.5708 |  2   |  3
 3.1416 |  0   |  0
 4.7124 |  2   |  3
X=-4.71238898038
```

Not an identity

(c) Answers will vary.
47–49. Answers will vary.

51. (a) Answers will vary.
(b) *Sample answer:*

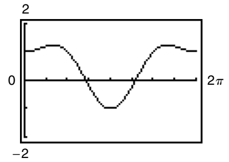
θ	5°	15°	30°	45°	60°	75°	90°
s	57.15	18.66	8.66	5	2.89	1.34	0

(c) Minimum: 90° (d) Noon
53. False. $(1 + \csc x)(1 - \csc x) = 1 - \csc x + \csc x - \csc^2 x$
$= 1 - \csc^2 x = -\cot^2 x$
55. $\cot(-x) = -\cot x$
57. The equation is not an identity because $\tan\theta = \pm\sqrt{\sec^2\theta - 1}$.
Sample answer: $\dfrac{3\pi}{4}$
59. $x = -2, 17$ **61.** $x = -9, 7$
63. (a) $\theta = 0° = 0, \theta = 180° = \pi$
(b) $\theta = 45° = \dfrac{\pi}{4}, \theta = 135° = \dfrac{3\pi}{4}$

Section 5.3 *(page 370)*

1. isolate **3.** quadratic **5.** $\cos 0 = 1$
7–11. Answers will vary.
13. $\dfrac{\pi}{3} + 2n\pi, \dfrac{2\pi}{3} + 2n\pi$ **15.** $\dfrac{2\pi}{3} + 2n\pi, \dfrac{4\pi}{3} + 2n\pi$
17. $\dfrac{\pi}{6} + n\pi, \dfrac{5\pi}{6} + n\pi$ **19.** $\dfrac{\pi}{3} + n\pi, \dfrac{2\pi}{3} + n\pi$
21. $n\pi, \dfrac{3\pi}{2} + 2n\pi$ **23.** $\dfrac{n\pi}{2}$
25. $n\pi, \dfrac{\pi}{6} + n\pi, \dfrac{5\pi}{6} + n\pi$
27. $\dfrac{\pi}{3} + 2n\pi, \pi + 2n\pi, \dfrac{5\pi}{3} + 2n\pi$
29. $\pi + 2n\pi, \dfrac{\pi}{3} + 2n\pi, \dfrac{5\pi}{3} + 2n\pi$ **31.** $\dfrac{\pi}{4}, \dfrac{5\pi}{4}$
33. $\dfrac{\pi}{2}, \dfrac{3\pi}{2}, \dfrac{2\pi}{3}, \dfrac{4\pi}{3}$ **35.** $\dfrac{\pi}{3}, \dfrac{2\pi}{3}, \dfrac{4\pi}{3}, \dfrac{5\pi}{3}$ **37.** No solution
39. $\dfrac{\pi}{2}$ **41.** $\dfrac{\pi}{6} + n\pi, \dfrac{5\pi}{6} + n\pi$ **43.** $\dfrac{\pi}{12} + \dfrac{n\pi}{3}$
45. $\dfrac{\pi}{2} + 4n\pi, \dfrac{7\pi}{2} + 4n\pi$ **47.** $\dfrac{\pi}{3} + 2n\pi$ **49.** $3 + 4n$
51. 3.553, 5.872 **53.** 1.249, 4.391 **55.** 0.739
57. 0.955, 2.186, 4.097, 5.328 **59.** 1.221, 1.921, 4.362, 5.062
61. $\arctan(-4) + n\pi, \arctan 3 + n\pi$
63. $\dfrac{\pi}{4} + n\pi, \arctan 5 + n\pi$
65. $\dfrac{\pi}{3} + 2n\pi, \dfrac{5\pi}{3} + 2n\pi$
67. $\arctan\frac{1}{3} + n\pi, \arctan\left(-\frac{1}{3}\right) + n\pi$
69. $\arccos\frac{1}{4} + 2n\pi, -\arccos\frac{1}{4} + 2n\pi$
71. $\dfrac{\pi}{2} + 2n\pi, \arcsin\left(-\dfrac{1}{4}\right) + 2n\pi, \arcsin\dfrac{1}{4} + 2n\pi$
73. 0.3398, 0.8481, 2.2935, 2.8018
75. 1.9357, 2.7767, 5.0773, 5.9183
77. −1.154, 0.534
79. 1.110

81. (a)



(b) $\frac{\pi}{3} \approx 1.0472$

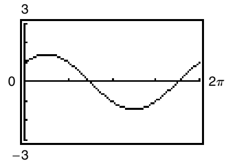
$\frac{5\pi}{3} \approx 5.2360$

0

$\pi \approx 3.1416$

Maximum: $(1.0472, 1.25)$
Maximum: $(5.2360, 1.25)$
Minimum: $(0, 1)$
Minimum: $(3.1416, -1)$

83. (a)

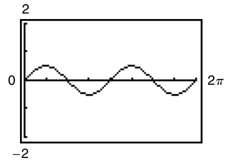


(b) $\frac{\pi}{4} \approx 0.7854$

$\frac{5\pi}{4} \approx 3.9270$

Maximum: $(0.7854, 1.4142)$
Minimum: $(3.9270, -1.4142)$

85. (a)



(b) $\frac{\pi}{4} \approx 0.7854$

$\frac{5\pi}{4} \approx 3.9270$

$\frac{3\pi}{4} \approx 2.3562$

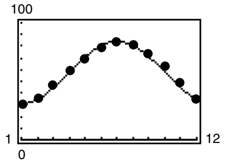
$\frac{7\pi}{4} \approx 5.4978$

Maximum: $(0.7854. 0.5)$
Maximum: $(3.9270, 0.5)$
Minimum: $(2.3562, -0.5)$
Minimum: $(5.4978, -0.5)$

87. 1 **89.** 0.04 sec, 0.43 sec, 0.83 sec

91. January, November, December

93. (a) and (c)

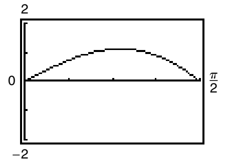


The model fits the data well.

(b) $C = 26.55 \cos\left(\frac{\pi t}{6} - \frac{7\pi}{6}\right) + 57.55$

(d) Above 72°F: June through September
Below 72°F: October through May

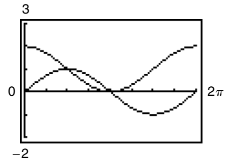
95. (a)



$A \approx 1.12$

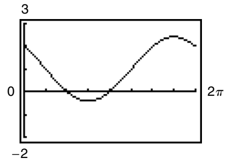
(b) $0.6 < x < 1.1$

97. (a)



Graphs intersect when $x = \frac{\pi}{2}$ and $x = \pi$.

(b)



x-intercepts: $\left(\frac{\pi}{2}, 0\right), (\pi, 0)$

(c) Yes; Answers will vary.

99. 1

101. True. The first equation has a smaller period than the second equation, so it will have more solutions in the interval $[0, 2\pi)$.

103. The equation becomes $\cos^2 x = 2$; No

105. $x = 2 \pm 2\sqrt{3}$ **107.** $x = -1 \pm \sqrt{22}$

109. $x = 6 \pm 2\sqrt{5}$ **111.** $x = \pm 1$

113. $\frac{\sqrt{4 - x^2}}{x}, 0 < x \le 2$ **115.** $\frac{x}{\sqrt{x^2 - 9}}, x > 3$

117. $x, 0 \le x < 2$

Section 5.4 *(page 378)*

1. $\sin u \cos v - \cos u \sin v$ **3.** $\frac{\tan u + \tan v}{1 - \tan u \tan v}$

5. $\cos u \cos v + \sin u \sin v$

7. *Sample answer:* $\sin\left(\frac{\pi}{6} + \frac{\pi}{4}\right)$

9. (a) $\frac{\sqrt{2} - \sqrt{6}}{4}$ (b) $\frac{\sqrt{2} + 1}{2}$

11. (a) $\frac{\sqrt{6} + \sqrt{2}}{4}$ (b) $\frac{\sqrt{2} - \sqrt{3}}{2}$

13. $\sin \frac{11\pi}{12} = \frac{\sqrt{2}}{4}\left(\sqrt{3} - 1\right)$

$\cos \frac{11\pi}{12} = -\frac{\sqrt{2}}{4}\left(\sqrt{3} + 1\right)$

$\tan \frac{11\pi}{12} = -2 + \sqrt{3}$

15. $\sin \frac{17\pi}{12} = -\frac{\sqrt{2}}{4}\left(\sqrt{3} + 1\right)$

$\cos \frac{17\pi}{12} = \frac{\sqrt{2}}{4}\left(1 - \sqrt{3}\right)$

$\tan \frac{17\pi}{12} = 2 + \sqrt{3}$

17. $\sin 105° = \frac{\sqrt{2}}{4}\left(\sqrt{3} + 1\right)$

$\cos 105° = \frac{\sqrt{2}}{4}\left(1 - \sqrt{3}\right)$

$\tan 105° = -2 - \sqrt{3}$

19. $\sin(-195°) = \frac{\sqrt{2}}{4}\left(\sqrt{3} - 1\right)$

$\cos(-195°) = -\frac{\sqrt{2}}{4}\left(\sqrt{3} + 1\right)$

$\tan(-195°) = -2 + \sqrt{3}$

21. $\sin \frac{13\pi}{12} = \frac{\sqrt{2}}{4}\left(1 - \sqrt{3}\right)$

$\cos \frac{13\pi}{12} = -\frac{\sqrt{2}}{4}\left(1 + \sqrt{3}\right)$

$\tan \frac{13\pi}{12} = 2 - \sqrt{3}$

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23. $\sin\left(-\frac{5\pi}{12}\right) = -\frac{\sqrt{2}}{4}\left(1 + \sqrt{3}\right)$

$\cos\left(-\frac{5\pi}{12}\right) = \frac{\sqrt{2}}{4}\left(\sqrt{3} - 1\right)$

$\tan\left(-\frac{5\pi}{12}\right) = -2 - \sqrt{3}$

25. $\sin 285° = -\frac{\sqrt{2}}{4}\left(\sqrt{3} + 1\right)$

$\cos 285° = \frac{\sqrt{2}}{4}\left(\sqrt{3} - 1\right)$

$\tan 285° = -\left(2 + \sqrt{3}\right)$

27. $\sin(-165°) = -\frac{\sqrt{2}}{4}\left(\sqrt{3} - 1\right)$

$\cos(-165°) = -\frac{\sqrt{2}}{4}\left(1 + \sqrt{3}\right)$

$\tan(-165°) = 2 - \sqrt{3}$

29. $\sin 1.8$ **31.** $\cos 170°$ **33.** $\tan\frac{7\pi}{15}$

35. $\cos(3x - 2y)$ **37.** $\frac{\sqrt{3}}{2}$ **39.** $-\frac{1}{2}$

41. 0 **43.** $-\frac{13}{85}$ **45.** $-\frac{13}{84}$ **47.** $\frac{85}{36}$ **49.** $\frac{3}{5}$

51. $-\frac{44}{117}$ **53.** $-\frac{125}{44}$ **55.** 1 **57.** 0

59–65. Answers will vary. **67.** $-\sin\theta$ **69.** $-\sec\theta$

71–73. Answers will vary.

75. (a) $\sqrt{2}\sin\left(\theta + \frac{\pi}{4}\right)$ (b) $\sqrt{2}\cos\left(\theta - \frac{\pi}{4}\right)$

77. (a) $13\sin(3\theta + 0.3948)$ (b) $13\cos(3\theta - 1.1760)$

79. $\sqrt{2}\sin\theta + \sqrt{2}\cos\theta$

81. (a) $y = \frac{5}{12}\sin(2t + 0.6435)$ (b) $\frac{5}{12}$ ft (c) $\frac{1}{\pi}$ cycle/sec

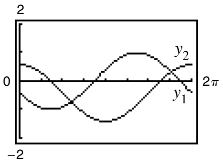
83. $\frac{\pi}{6}, \frac{5\pi}{6}$ **85.** $\frac{5\pi}{4}, \frac{7\pi}{4}$ **87.** $0, \frac{\pi}{3}, \pi, \frac{5\pi}{3}$

89. $\frac{\pi}{4}, \frac{7\pi}{4}$ **91.** $\frac{\pi}{2}, \pi, \frac{3\pi}{2}$

93. True. $\sin(u \pm v) = \sin u\cos v \pm \cos u\sin v$

95. The denominator should be $1 - \tan x\tan\frac{\pi}{4} = 1 - \tan x$.

97.



No, $y_1 \neq y_2$ because their graphs are different.

99. Proof

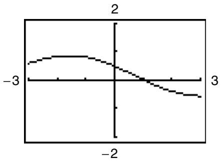
101. (a) All real numbers h except $h = 0$

(b)

h	0.5	0.2	0.1
$f(h)$	0.267	0.410	0.456
$g(h)$	0.267	0.410	0.456

h	0.05	0.02	0.01
$f(h)$	0.478	0.491	0.496
$g(h)$	0.478	0.491	0.496

(c)



(d) As $h \to 0^+$, $f \to 0.5$ and $g \to 0.5$.

103. $\sin\theta = -\frac{12}{13}$

$\tan\theta = -\frac{12}{5}$

$\csc\theta = -\frac{13}{12}$

$\sec\theta = \frac{13}{5}$

$\cot\theta = -\frac{5}{12}$

105. $\sin\theta = \frac{\sqrt{5}}{5}$

$\cos\theta = -\frac{2\sqrt{5}}{5}$

$\csc\theta = \sqrt{5}$

$\sec\theta = -\frac{\sqrt{5}}{2}$

$\cot\theta = -2$

107. $x = \frac{\pi}{2} + 2\pi$ **109.** $x = \frac{3\pi}{2} + 2n\pi$ **111.** $x = \frac{\pi}{6} + \frac{n\pi}{3}$

Section 5.5 *(page 388)*

1. $\cos 2u$

3. *Sample answer:* Product-to-sum formulas are used in calculus to solve problems involving the products of sines and cosines of two different angles.

5. $n\pi, \frac{\pi}{3} + 2n\pi, \frac{5\pi}{3} + 2n\pi$ **7.** $\frac{2n\pi}{3}$ **9.** $\frac{n\pi}{2}$

11. $\frac{\pi}{6} + n\pi, \frac{\pi}{2} + n\pi, \frac{5\pi}{6} + n\pi$ **13.** $3\sin 2x$

15. $3\cos 2x$ **17.** $4\cos 2x$

19. $\sin 2u = -\frac{24}{25}$, $\cos 2u = \frac{7}{25}$, $\tan 2u = -\frac{24}{7}$

21. $\sin 2u = \frac{15}{17}$, $\cos 2u = \frac{8}{17}$, $\tan 2u = \frac{15}{8}$

23. $8\cos^4 x - 8\cos^2 x + 1$ **25.** $\frac{1}{8}(3 + 4\cos 2x + \cos 4x)$

27. $\frac{1}{8}(3 - 4\cos 4x + \cos 8x)$ **29.** $\frac{(3 - 4\cos 4x + \cos 8x)}{(3 + 4\cos 4x + \cos 8x)}$

31. $\frac{1}{8}(1 - \cos 8x)$

33. $\sin 75° = \frac{1}{2}\sqrt{2 + \sqrt{3}}$

$\cos 75° = \frac{1}{2}\sqrt{2 - \sqrt{3}}$

$\tan 75° = 2 + \sqrt{3}$

35. $\sin 112° 30' = \frac{1}{2}\sqrt{2 + \sqrt{2}}$

$\cos 112° 30' = -\frac{1}{2}\sqrt{2 - \sqrt{2}}$

$\tan 112° 30' = -1 - \sqrt{2}$

37. $\sin\frac{\pi}{8} = \frac{1}{2}\sqrt{2 - \sqrt{2}}$

$\cos\frac{\pi}{8} = \frac{1}{2}\sqrt{2 + \sqrt{2}}$

$\tan\frac{\pi}{8} = \sqrt{2} - 1$

39. (a) Quadrant I

(b) $\sin\frac{u}{2} = \frac{3}{5}$, $\cos\frac{u}{2} = \frac{4}{5}$, $\tan\frac{u}{2} = \frac{3}{4}$

41. (a) Quadrant II

(b) $\sin\frac{u}{2} = \frac{\sqrt{26}}{26}$, $\cos\frac{u}{2} = -\frac{5\sqrt{26}}{26}$, $\tan\frac{u}{2} = -\frac{1}{5}$

43. π **45.** $\frac{\pi}{3}, \pi, \frac{5\pi}{3}$ **47.** $\frac{1}{2}(\cos 2\theta - \cos 8\theta)$

49. $\frac{1}{2}(\cos(-2\theta) + \cos 6\theta)$ **51.** $2\cos 4\theta\sin\theta$

53. $2\cos 4x\cos 2x$ **55.** $\frac{\sqrt{6}}{2}$ **57.** $-\sqrt{2}$

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59. $0, \frac{\pi}{4}, \frac{\pi}{2}, \frac{3\pi}{4}, \pi, \frac{5\pi}{4}, \frac{3\pi}{2}, \frac{7\pi}{4}$ **61.** $\frac{\pi}{6}, \frac{5\pi}{6}$

63–65. Answers will vary.

67. (a) $\cos\theta = \frac{M^2 - 2}{M^2}$ (b) $\frac{\pi}{3}$ (c) 1520 mi/h

69. Answers will vary.

71. True. $\sin(-2x) = 2\sin(-x)\cos(-x) = -2\sin x\cos x$.

73. $B = 63°$ **75.** $B = C = 45°$ **77.** 0.8829

79. -1.4945

81. (a) About 104.95 nm south, about 58.18 nm west
(b) S 36.7° W; about 130.9 nm

Review Exercises *(page 392)*

1. $\cot x$ **3.** $\cos x$

5. $\sin\theta = -\frac{\sqrt{21}}{5}$ $\csc\theta = -\frac{5\sqrt{21}}{21}$
$\cos\theta = -\frac{2}{5}$ $\sec\theta = -\frac{5}{2}$
$\tan\theta = \frac{\sqrt{21}}{2}$ $\cot\theta = \frac{2\sqrt{21}}{21}$

7. $\sin^2 x$ **9.** 1 **11.** $\tan u \sec u$ **13.** $\cot^2 x$

15. $-2\tan^2\theta$ **17.** $5\cos\theta$ **19–25.** Answers will vary.

27. $\frac{\pi}{3} + 2n\pi, \frac{2\pi}{3} + 2n\pi$ **29.** $\frac{\pi}{6} + n\pi$

31. $\frac{\pi}{3} + n\pi, \frac{2\pi}{3} + n\pi$ **33.** $0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$ **35.** $0, \frac{\pi}{2}, \pi$

37. $\frac{\pi}{8}, \frac{3\pi}{8}, \frac{9\pi}{8}, \frac{11\pi}{8}$ **39.** $\frac{\pi}{2}$

41. $0, \frac{\pi}{8}, \frac{3\pi}{8}, \frac{5\pi}{8}, \frac{7\pi}{8}, \frac{9\pi}{8}, \frac{11\pi}{8}, \frac{13\pi}{8}, \frac{15\pi}{8}$

43. $n\pi, \arctan 2 + n\pi$ **45.** $\arctan(-3) + n\pi, \arctan 2 + n\pi$

47. $\sin 75° = \frac{\sqrt{2}}{4}(1 + \sqrt{3})$
$\cos 75° = \frac{\sqrt{2}}{4}(\sqrt{3} - 1)$
$\tan 75° = 2 + \sqrt{3}$

49. $\sin\frac{25\pi}{12} = \frac{\sqrt{2}}{4}(\sqrt{3} - 1)$
$\cos\frac{25\pi}{12} = \frac{\sqrt{2}}{4}(\sqrt{3} + 1)$
$\tan\frac{25\pi}{12} = 2 - \sqrt{3}$

51. $\sin\left(\frac{-19\pi}{12}\right) = \frac{\sqrt{2}}{4}(\sqrt{3} + 1)$
$\cos\left(\frac{-19\pi}{12}\right) = \frac{\sqrt{2}}{4}(\sqrt{3} - 1)$
$\tan\left(\frac{-19\pi}{12}\right) = 2 + \sqrt{3}$

53. $\sin 15°$ **55.** $-\frac{24}{25}$ **57.** -1

59–61. Answers will vary. **63.** $\frac{\pi}{4}, \frac{7\pi}{4}$

65. *Sample answer:* $4\sin x\cos x - 8\sin^3 x\cos x$

67. $8\cos^3 x\sin x - 4\cos x\sin x$

69. $\frac{1 - \cos 6x}{1 + \cos 6x}$

71. $\sin(-75°) = -\frac{1}{2}\sqrt{2 + \sqrt{3}}$
$\cos(-75°) = \frac{1}{2}\sqrt{2 - \sqrt{3}}$
$\tan(-75°) = -2 - \sqrt{3}$

73. (a) Quadrant II
(b) $\sin\frac{u}{2} = \frac{2\sqrt{5}}{5}, \cos\frac{u}{2} = -\frac{\sqrt{5}}{5}, \tan\frac{u}{2} = -2$

75. (a) Quadrant I
(b) $\sin\frac{u}{2} = \frac{3\sqrt{14}}{14}, \cos\frac{u}{2} = \frac{\sqrt{70}}{14}, \tan\frac{u}{2} = \frac{3\sqrt{5}}{5}$

77. $\frac{1}{2}[\sin 10\theta - \sin(-2\theta)]$ **79.** $2\cos\frac{11\theta}{2}\cos\frac{\theta}{2}$

81. $\theta = 15°$ or $\frac{\pi}{12}$

83. False. If $(\pi/2) < \theta < \pi$, then $\theta/2$ lies in Quadrant I.

85. False. $\begin{aligned} 4\sin(-x)\cos(-x) &= 4(-\sin x)\cos x \\ &= -4\sin x\cos x \\ &= -2(2\sin x\cos x) \\ &= -2\sin 2x \end{aligned}$

87. Yes. *Sample answer:* $\sin x = \frac{1}{2}$ has an infinite number of solutions.

Chapter Test *(page 394)*

1. $\sin\theta = \frac{2}{5}$ $\csc\theta = \frac{5}{2}$
$\cos\theta = -\frac{\sqrt{21}}{5}$ $\sec\theta = -\frac{5\sqrt{21}}{21}$
$\tan\theta = -\frac{2\sqrt{21}}{21}$ $\cot\theta = -\frac{\sqrt{21}}{2}$

2. 1 **3.** 1 **4.** $\csc\theta\sec\theta$ **5–10.** Answers will vary.

11. $2(\sin 5\theta + \sin\theta)$ **12.** $-2\sin\theta$

13. $0, \frac{3\pi}{4}, \pi, \frac{7\pi}{4}$ **14.** $\frac{\pi}{6}, \frac{\pi}{2}, \frac{5\pi}{6}, \frac{3\pi}{2}$ **15.** $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$

16. $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{3\pi}{2}$ **17.** 0, 2.596 **18.** $\frac{\sqrt{2} - \sqrt{6}}{4}$

19. $\sin 2u = -\frac{20}{29}, \cos 2u = -\frac{21}{29}, \tan 2u = \frac{20}{21}$

20. Day 30 to day 310

21. 0.26 min, 0.58 min, 0.89 min, 1.20 min, 1.52 min, 1.83 min

Problem Solving *(page 397)*

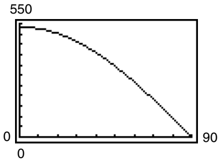
1. $\sin\theta = \pm\sqrt{1 - \cos^2\theta}$
$\tan\theta = \pm\frac{\sqrt{1 - \cos^2\theta}}{\cos\theta}$
$\csc\theta = \pm\frac{1}{\sqrt{1 - \cos^2\theta}}$
$\sec\theta = \frac{1}{\cos\theta}$
$\cot\theta = \pm\frac{\cos\theta}{\sqrt{1 - \cos^2\theta}}$

3. Answers will vary. **5.** $u + v = w$; Proof

7. (a) $A = 100\sin\frac{\theta}{2}\cos\frac{\theta}{2}$ (b) $A = 50\sin\theta; \theta = \frac{\pi}{2}$

9. (a) $F = \frac{0.6W\cos\theta}{\sin 12°}$

(b)



(c) Maximum: $\theta = 0°$
Minimum: $\theta = 90°$

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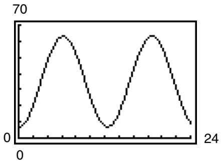
11. (a) High tides: 6:12 A.M., 6:36 P.M.
Low tides: 12:00 A.M., 12:24 P.M.
(b) The water depth never falls below 7 feet.
(c)



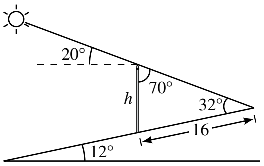
13. (a) $n = \frac{1}{2}\left(\cot\frac{\theta}{2} + \sqrt{3}\right)$ (b) $\theta \approx 76.5°$

15. (a) $\frac{\pi}{6} \le x \le \frac{5\pi}{6}$ (b) $\frac{2\pi}{3} \le x \le \frac{4\pi}{3}$
(c) $\frac{\pi}{2} < x < \pi, \frac{3\pi}{2} < x < 2\pi$
(d) $0 \le x \le \frac{\pi}{4}, \frac{5\pi}{4} \le x < 2\pi$

Chapter 6

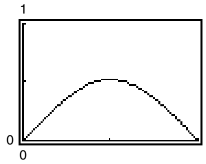
Section 6.1 *(page 406)*

1. oblique **3.** AAS or ASA, and SSA
5. $A = 30°, a \approx 14.14, c \approx 27.32$
7. $C = 105°, a \approx 5.94, b \approx 6.65$
9. $B = 60.9°, b \approx 19.32, c \approx 6.36$
11. $B = 42°\,4', a \approx 22.05, b \approx 14.88$
13. $C = 80°, a \approx 5.82, b \approx 9.20$
15. $B = 83°, a = 0.51, c = 0.62$
17. $B \approx 21.55°, C \approx 122.45°, c \approx 11.49$
19. $B \approx 9.43°, C \approx 25.57°, c \approx 10.53$
21. $A \approx 10°\,11', C \approx 154°\,19', c \approx 11.03$
23. $B \approx 48.74°, C \approx 21.26°, c \approx 48.23$ **25.** No solution
27. Two solutions:
$B \approx 72.21°, C \approx 49.79°, c \approx 10.27$
$B \approx 107.79°, C \approx 14.21°, c \approx 3.30$
29. No solution
31. $B = 45°, C = 90°, c \approx 1.41$
33. (a) $b \le 5, b = \frac{5}{\sin 36°}$ (b) $5 < b < \frac{5}{\sin 36°}$
(c) $b > \frac{5}{\sin 36°}$
35. (a) $b < 80$ (b) Not possible (c) $b \ge 80$
37. 22.1 **39.** 94.4 **41.** 218.0 **43.** 22.3
45. From Pine Knob: about 42.4 km
From Colt Station: about 15.5 km
47. About 77 m
49. (a) $\frac{h}{\sin 30°} = \frac{40}{\sin 56°}$ (b) About 24.1 m
51. (a)



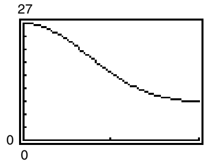
(b) $\frac{16}{\sin 70°} = \frac{h}{\sin 32°}$
(c) About 9 m

53. (a) $\alpha = \arcsin(0.5 \sin \beta)$
(b)



Domain: $0 < \beta < \pi$
Range: $0 < \alpha < \frac{\pi}{6}$

(c) $c = \frac{18 \sin[\pi - \beta - \arcsin(0.5 \sin \beta)]}{\sin \beta}$
(d)



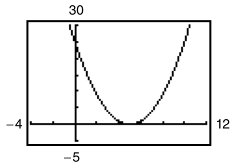
Domain: $0 < \beta < \pi$
Range: $9 < c < 27$

(e)

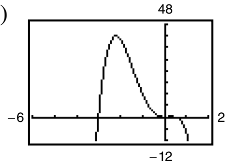
β	0.4	0.8	1.2	1.6	2.0	2.4	2.8
α	0.1960	0.3669	0.4848	0.5234	0.4720	0.3445	0.1683
c	25.95	23.07	19.19	15.33	12.29	10.31	9.27

As β increases from 0 to π, α increases and then decreases, and c decreases from 27 to 9.

55. True. If an angle of a triangle is obtuse, then the other two angles must be acute.
57. False. When just three angles are known, the triangle cannot be solved.
59. False. The sine of the angle included between the sides is needed.
61. $\frac{3}{2}$ **63.** 0
65. (a) 5 (b) Even multiplicity (c) 1
(d)



67. (a) $-3, 0, \frac{1}{2}$
(b) $-3, \frac{1}{2}$, odd multiplicity; 0, even multiplicity (c) 3
(d)



Section 6.2 *(page 413)*

1. alternative **3.** $\cos B = \frac{a^2 + c^2 - b^2}{2ac}$
5. $A \approx 38.62°, B \approx 48.51°, C \approx 92.87°$
7. $A = 17.61°, B = 28.96°, C = 133.43°$
9. $B \approx 23.79°, C \approx 126.21°, a \approx 18.59$

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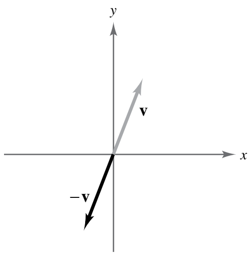
11. $A \approx 43.31°$, $B \approx 28.69°$, $c \approx 13.87$
13. $A \approx 30.11°$, $B \approx 43.16°$, $C \approx 106.73°$
15. $A \approx 132.77°$, $B \approx 31.91°$, $C \approx 15.32°$
17. $B \approx 27.46°$, $C \approx 32.54°$, $a \approx 11.27$
19. $A \approx 141° 45'$, $C \approx 27° 40'$, $b \approx 11.87$
21. $A = 27° 10'$, $C = 27° 10'$, $b \approx 65.84$
23. $A \approx 33.80°$, $B \approx 103.20°$, $c \approx 0.54$
25. 12.07; 5.69; 135° **27.** 13.86; 68.2°; 111.8°
29. 16.96; 77.2°; 102.8°
31. Law of Cosines; $A \approx 102.44°$, $C \approx 37.56°$, $b \approx 5.26$
33. Law of Sines; No solution
35. Law of Sines; $C = 103°$, $a \approx 0.82$, $b \approx 0.71$
37. 23.53 **39.** 5.35 **41.** 0.24 **43.** 1514.14
45. About 373.3 m **47.** About 103.9 ft
49. (a) N 59.7° E (b) N 72.8° E **51.** 41.2°, 52.9°
53. 72.3° **55.** About 46,837.5 ft^2 **57.** $83,336.37
59. False. For s to be the average of the lengths of the three sides of the triangle, s would be equal to $(a + b + c)/3$.
61. $c^2 = a^2 + b^2$; The Pythagorean Theorem is a special case of the Law of Cosines.
63. Proof
65. (a) $\frac{7}{4}$ (b) $\sqrt{65}$ **67.** (a) $-\frac{1}{4}$ (b) $\sqrt{17}$
69. (a) 0 (b) 6 **71.** (a) $\frac{5}{6}$ (b) $4\sqrt{61}$
73. (a) $\sin\theta = \frac{\sqrt{2}}{2}$ $\csc = \sqrt{2}$
$\cos\theta = -\frac{\sqrt{2}}{2}$ $\sec\theta = -\sqrt{2}$
$\tan\theta = -1$ $\cot\theta = -1$

(b) $\sin\theta = -\frac{\sqrt{2}}{2}$ $\csc\theta = -\sqrt{2}$
$\cos\theta = \frac{\sqrt{2}}{2}$ $\sec = \sqrt{2}$
$\tan\theta = -1$ $\cot\theta = -1$

Section 6.3 *(page 425)*

1. directed line segment **3.** multiplication; addition
5. Two vectors are equivalent if they have the same magnitude and direction.
7. Equivalent; **u** and **v** have the same magnitude and direction.
9. Not equivalent; **u** and **v** do not have the same direction.
11. Equivalent; **u** and **v** have the same magnitude and direction.
13. $\mathbf{v} = \langle 1, 3\rangle$, $\|\mathbf{v}\| = \sqrt{10}$ **15.** $\mathbf{v} = \langle 0, 5\rangle$; $\|\mathbf{v}\| = 5$
17. $\mathbf{v} = \langle -8, 6\rangle$; $\|\mathbf{v}\| = 10$ **19.** $\mathbf{v} = \langle -9, -12\rangle$; $\|\mathbf{v}\| = 15$
21. $\mathbf{v} = \langle 16, -26\rangle$; $\|\mathbf{v}\| = 2\sqrt{233}$

23.



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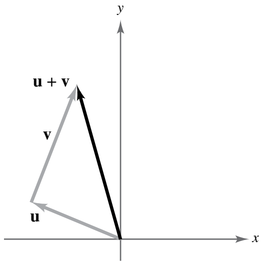
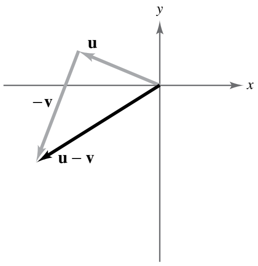
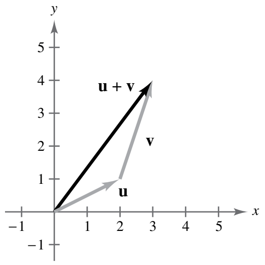


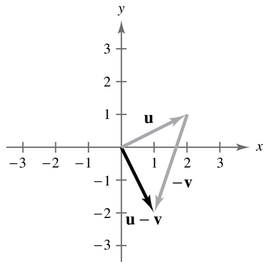
27.



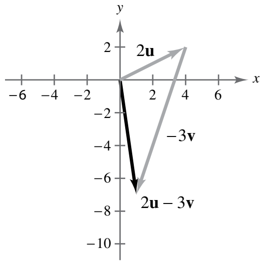
29. (a) $\langle 3, 4\rangle$



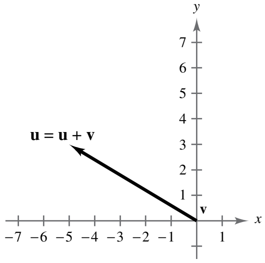
(b) $\langle 1, -2\rangle$



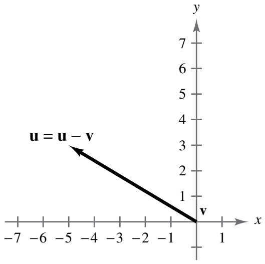
(c) $\langle 1, -7\rangle$



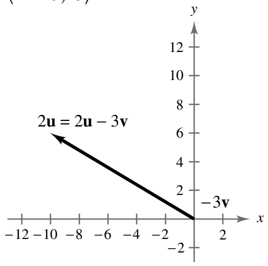
31. (a) $\langle -5, 3\rangle$



(b) $\langle -5, 3\rangle$



(c) $\langle -10, 6\rangle$



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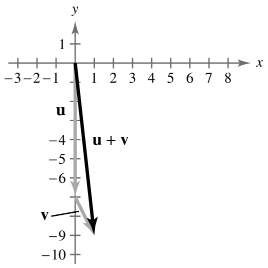
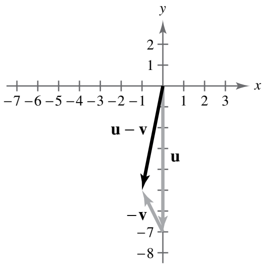
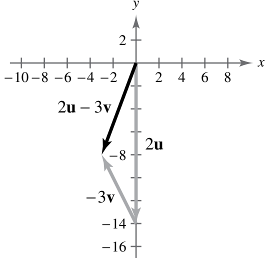
33. (a) $\langle 1, -9\rangle$



(b) $\langle -1, -5\rangle$



(c) $\langle -3, -8\rangle$

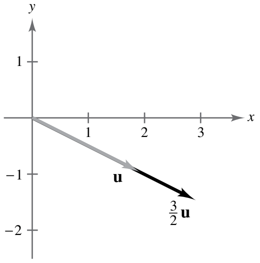


35. 10 **37.** $9\sqrt{5}$ **39.** $\langle 1, 0\rangle$ **41.** $\left\langle -\frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2}\right\rangle$

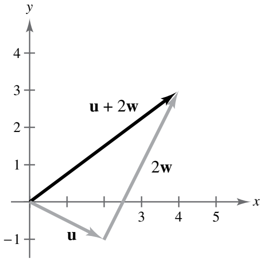
43. $\left\langle \frac{\sqrt{37}}{37}, -\frac{6\sqrt{37}}{37}\right\rangle$ **45.** $\mathbf{v} = \langle -6, 8\rangle$

47. $\mathbf{v} = \left\langle \frac{18\sqrt{29}}{29}, \frac{45\sqrt{29}}{29}\right\rangle$ **49.** $5\mathbf{i} - 3\mathbf{j}$ **51.** $-6\mathbf{i} + 3\mathbf{j}$

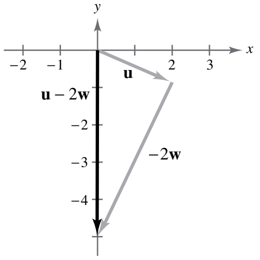
53. $\mathbf{v} = \langle 3, -\frac{3}{2}\rangle$



55. $\mathbf{v} = \langle 4, 3\rangle$

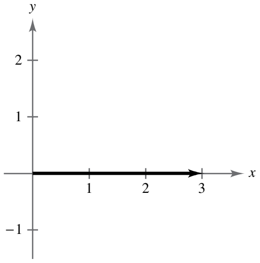


57. $\mathbf{v} = \langle 0, -5\rangle$

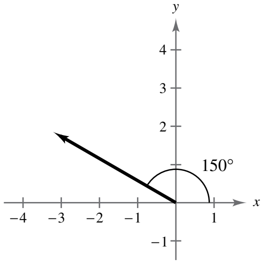


59. $\|\mathbf{v}\| = 6\sqrt{2}$; $\theta = 315°$ **61.** $\|\mathbf{v}\| = 3$; $\theta = 60°$

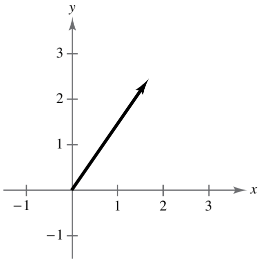
63. $\mathbf{v} = \langle 3, 0\rangle$



65. $\mathbf{v} = \left\langle -\frac{7\sqrt{3}}{4}, \frac{7}{4}\right\rangle$



67. $\mathbf{v} = \left\langle \frac{9}{5}, \frac{12}{5}\right\rangle$



69. $\langle 2, 4 + 2\sqrt{3}\rangle$ **71.** 90° **73.** About 62.7°

75. Vertical ≈ 2.30 ft/sec, horizontal ≈ 21.88 ft/sec

77. About 12.8°; about 398.32 N

79. About 71.3°; about 228.5 lb

81. $T_L \approx 15{,}484$ lb
$T_R \approx 19{,}786$ lb

83. $\sqrt{2}$ lb; 1 lb **85.** About 20.8 lb **87.** About 19.5°

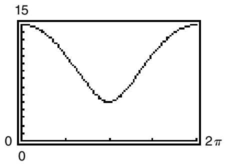
89. N 21.4° E; about 138.7 km/h

91. True. See Example 1. **93.** True. $a = b = 0$

95. $u_1 = 6 - (-3) = 9$ and $u_2 = -1 - 4 = -5$, so $\mathbf{u} = \langle 9, -5\rangle$.

97. Proof **99.** $\langle 1, 3\rangle$ or $\langle -1, -3\rangle$

101. (a) $5\sqrt{5 + 4\cos\theta}$
(b)



(c) Range: $[5, 15]$
Maximum is 15 when $\theta = 0$.
Minimum is 5 when $\theta = \pi$.
(d) The magnitudes of $\mathbf{F}_1$ and $\mathbf{F}_2$ are not the same.

103. 8.49 **105.** 3.16 **107.** 6.08 **109.** 17.09

111. $\frac{\pi}{2} + n\pi$ **113.** 1

115. $A = 21.00°$, $B = 18.57°$, $C = 140.43°$

117. $A = 37°$, $a = 12.10$, $b = 17.24$

Section 6.4 *(page 435)*

1. *Sample answer:* $\mathbf{u} \cdot (\mathbf{v} + \mathbf{w}) = \mathbf{u} \cdot \mathbf{v} + \mathbf{u} \cdot \mathbf{w}$

3. $\left(\frac{\mathbf{u} \cdot \mathbf{v}}{\|\mathbf{v}\|^2}\right)\mathbf{v}$ **5.** −19 **7.** 0 **9.** 6 **11.** 18; scalar

13. $\langle 24, -12\rangle$; vector **15.** $\mathbf{0}$; vector **17.** 60; scalar

19. $\sqrt{10} - 1$; scalar **21.** −12; scalar **23.** 17

25. $5\sqrt{41}$ **27.** 6 **29.** $\frac{\pi}{2}$ **31.** About 2.50

33. 0 **35.** About 0.93 **37.** $\frac{5\pi}{12}$ **39.** About 91.33°

41. 90° **43.** 26.57°, 63.43°, 90°

45. 41.63°, 53.13°, 85.24° **47.** −20 **49.** $12{,}500\sqrt{3}$

51. Not orthogonal **53.** Orthogonal **55.** Not orthogonal

57. $\frac{1}{37}\langle 84, 14\rangle$, $\frac{1}{37}\langle -10, 60\rangle$ **59.** $\langle 0, 0\rangle$, $\langle 4, 2\rangle$

61. $\langle 3, 2\rangle$ **63.** $\langle 0, 0\rangle$ **65.** $\langle -5, 3\rangle$, $\langle 5, -3\rangle$

67. $\frac{2}{3}\mathbf{i} + \frac{1}{2}\mathbf{j}$, $-\frac{2}{3}\mathbf{i} - \frac{1}{2}\mathbf{j}$ **69.** 32

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71. (a) \$35,727.50
This value gives the total amount paid to the employees.
(b) Multiply **v** by 1.02.

73. (a) Force = 30,000 sin d
(b)

d	0°	1°	2°	3°	4°	5°
Force	0	523.6	1047.0	1570.1	2092.7	2614.7

d	6°	7°	8°	9°	10°
Force	3135.9	3656.1	4175.2	4693.0	5209.4

(c) About 29,885.8 lb

75. 735 N-m **77.** About 779.4 ft-lb

79. About 1174.62 ft-lb

81. False. Work is represented by a scalar. **83.** 4

85. The dot product of two vectors is a scalar, not a vector.
$\langle 5, 8\rangle \cdot \langle -2, 7\rangle = 5(-2) + 8(7) = -10 + 56 = 46$

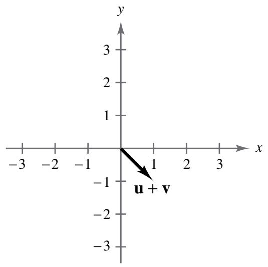
87. 1; $\mathbf{u} \cdot \mathbf{u} = \|\mathbf{u}\|^2$ **89.** Proof

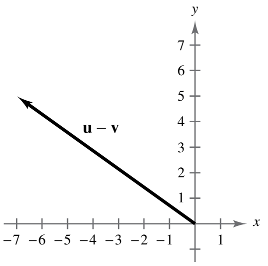
91. (a) 5 (b) $\left(\frac{3}{2}, 11\right)$ **93.** (a) $\sqrt{74}$ (b) $(0, 0)$

95. $-12 + 14i$ **97.** $-6 - 4i$ **99.** $1 - 3i$

101. 4

103. (a) $\langle 1, -1\rangle$ (b) $\langle -7, 5\rangle$





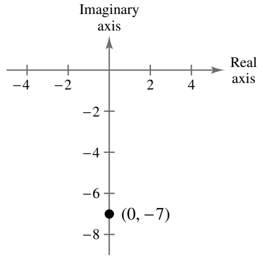
Section 6.5 *(page 443)*

1. real; imaginary

3. Reverse the sign of the imaginary part of the complex number.

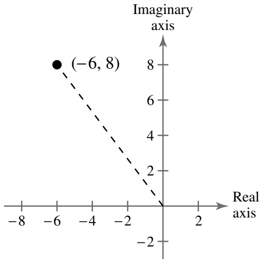
5. b **6.** d **7.** f **8.** a **9.** e **10.** c

11.



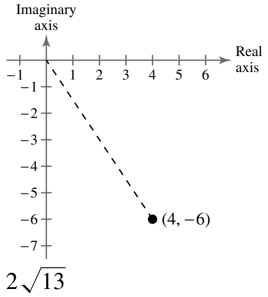
7

13.



10

15.

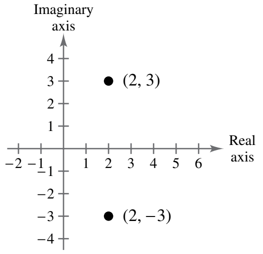


$2\sqrt{13}$

17. $5 + 6i$ **19.** $10 + 4i$ **21.** $1 + 7i$ **23.** $-2 - 2i$

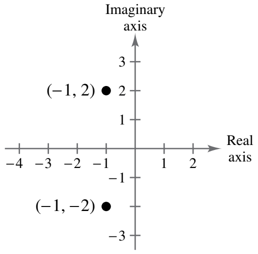
25. $10 - 3i$ **27.** $-6i$

29.



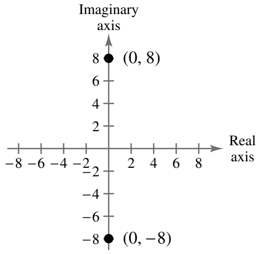
$2 - 3i$

31.



$-1 + 2i$

33.



$-8i$

35. $2\sqrt{2} \approx 2.83$ **37.** $\sqrt{109} \approx 10.44$ **39.** $(4, 3)$

41. $\left(\frac{9}{2}, -\frac{3}{2}\right)$

43. (a) Ship A: $3 + 4i$, Ship B: $-5 + 2i$
(b) *Sample answer:* Find the modulus of the difference of the complex numbers.

45. False. The modulus is always real.

47. False. $|1 + i| + |1 - i| = 2\sqrt{2}$ and $|(1 + i) + (1 - i)| = 2$

49. A circle; The modulus represents the distance from the origin.

51. $\pm i, -2$ **53.** $2 \pm 2i, 5$

55. $\sin\theta = \dfrac{4}{5}$
$\tan\theta = -\dfrac{4}{3}$
$\csc\theta = \dfrac{5}{4}$
$\sec\theta = -\dfrac{5}{3}$
$\cot\theta = -\dfrac{3}{4}$

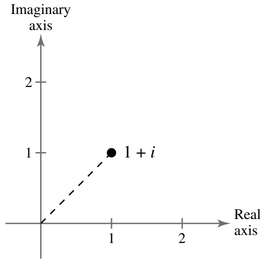
57. $\sin\theta = -\dfrac{5\sqrt{26}}{26}$
$\cos\theta = -\dfrac{\sqrt{26}}{26}$
$\csc\theta = -\dfrac{\sqrt{26}}{5}$
$\sec\theta = -\sqrt{26}$
$\cot\theta = \dfrac{1}{5}$

59. $\dfrac{7\pi}{6} + 2n\pi, \dfrac{11\pi}{6} + 2n\pi$ **61.** $\dfrac{\pi}{6} + n\pi, \dfrac{5\pi}{6} + n\pi$

Section 6.6 *(page 452)*

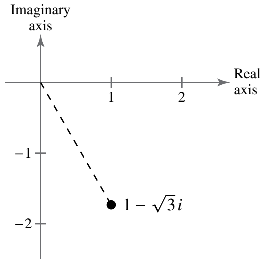
1. DeMoivre's **3.** r is the modulus and θ is an argument of z.

5.



$\sqrt{2}\left(\cos\dfrac{\pi}{4} + i\sin\dfrac{\pi}{4}\right)$

7.



$2\left(\cos\dfrac{5\pi}{3} + i\sin\dfrac{5\pi}{3}\right)$

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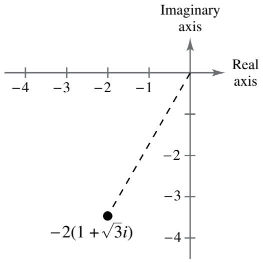
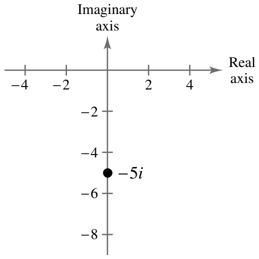
9.



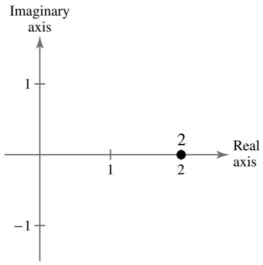
$4\left(\cos\frac{4\pi}{3} + i\sin\frac{4\pi}{3}\right)$

11.



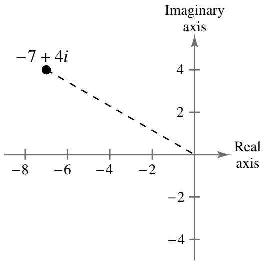
$5\left(\cos\frac{3\pi}{2} + i\sin\frac{3\pi}{2}\right)$

13.



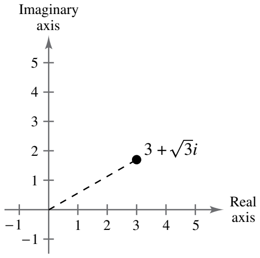
$2(\cos 0 + i\sin 0)$

15.



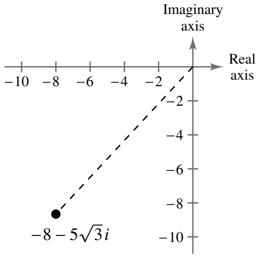
$\sqrt{65}\,(\cos 2.62 + i\sin 2.62)$

17.



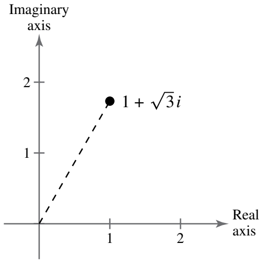
$2\sqrt{3}\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

19.

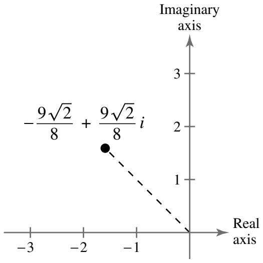


$\sqrt{139}(\cos 3.97 + i\sin 3.97)$

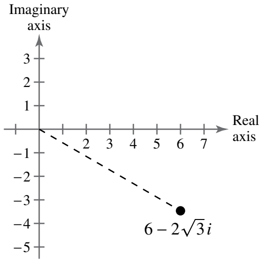
21. $1 + \sqrt{3}i$



23. $-\frac{9\sqrt{2}}{8} + \frac{9\sqrt{2}}{8}i$



25. $6 - 2\sqrt{3}i$



27. $4.6985 + 1.7101i$ **29.** $-1.8126 + 0.8452i$

31. $12\left(\cos\frac{\pi}{3} + i\sin\frac{\pi}{3}\right)$ **33.** $\frac{10}{9}(\cos 150° + i\sin 150°)$

35. $\frac{1}{3}(\cos 30° + i\sin 30°)$ **37.** $\cos\frac{2\pi}{3} + i\sin\frac{2\pi}{3}$

39. -1 **41.** $\frac{125}{2} + \frac{125\sqrt{3}}{2}i$ **43.** -1

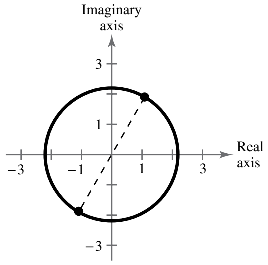
45. $608.0 + 144.7i$ **47.** $\frac{81}{2} + \frac{81\sqrt{3}}{2}i$ **49.** $-4 - 4i$

51. $8i$ **53.** $1024 - 1024\sqrt{3}i$

55. (a) $\sqrt{5}(\cos 60° + i\sin 60°)$
$\sqrt{5}(\cos 240° + i\sin 240°)$

(b) $\frac{\sqrt{5}}{2} + \frac{\sqrt{15}}{2}i, -\frac{\sqrt{5}}{2} - \frac{\sqrt{15}}{2}i$

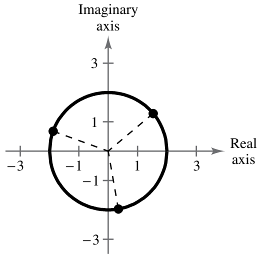
(c)



57. (a) $2\left(\cos\frac{2\pi}{9} + i\sin\frac{2\pi}{9}\right)$
$2\left(\cos\frac{8\pi}{9} + i\sin\frac{8\pi}{9}\right)$
$2\left(\cos\frac{14\pi}{9} + i\sin\frac{14\pi}{9}\right)$

(b) $1.5321 + 1.2856i$,
$-1.8794 + 0.6840i$,
$0.3473 - 1.9696i$

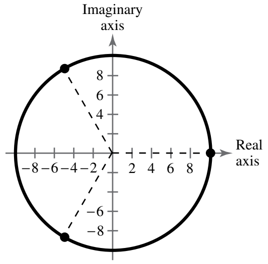
(c)



59. (a) $10(\cos 0 + i\sin 0)$
$10\left(\cos\frac{2\pi}{3} + i\sin\frac{2\pi}{3}\right)$
$10\left(\cos\frac{4\pi}{3} + i\sin\frac{4\pi}{3}\right)$

(b) $10, -5 + 5\sqrt{3}i$,
$-5 - 5\sqrt{3}i$

(c)



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61. (a) $\sqrt{2}\left(\cos\frac{\pi}{4} + i\sin\frac{\pi}{4}\right)$

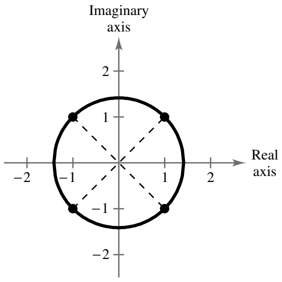
$\sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$

$\sqrt{2}\left(\cos\frac{5\pi}{4} + i\sin\frac{5\pi}{4}\right)$

$\sqrt{2}\left(\cos\frac{7\pi}{4} + i\sin\frac{7\pi}{4}\right)$

(b) $1 + i, -1 + i,$
$-1 - i, 1 - i$

(c)



63. (a) $\cos\frac{\pi}{8} + i\sin\frac{\pi}{8}$

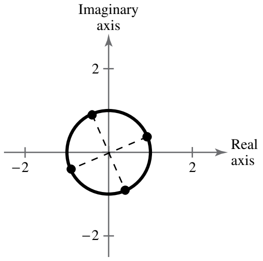
$\cos\frac{5\pi}{8} + i\sin\frac{5\pi}{8}$

$\cos\frac{9\pi}{8} + i\sin\frac{9\pi}{8}$

$\cos\frac{13\pi}{8} + i\sin\frac{13\pi}{8}$

(b) $0.9239 + 0.3827i,$
$-0.3827 + 0.9239i,$
$-0.9239 - 0.3827i,$
$0.3827 - 0.9239i$

(c)

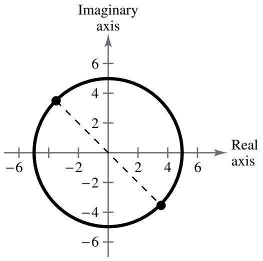


65. (a) $5\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$

$5\left(\cos\frac{7\pi}{4} + i\sin\frac{7\pi}{4}\right)$

(b) $-\frac{5\sqrt{2}}{2} + \frac{5\sqrt{2}}{2}i,$
$\frac{5\sqrt{2}}{2} - \frac{5\sqrt{2}}{2}i$

(c)



67. (a) $\sqrt{2}\left(\cos\frac{7\pi}{20} + i\sin\frac{7\pi}{20}\right)$

$\sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$

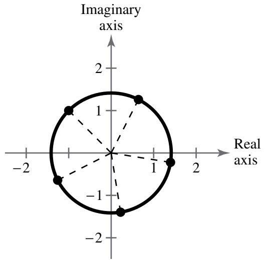
$\sqrt{2}\left(\cos\frac{23\pi}{20} + i\sin\frac{23\pi}{20}\right)$

$\sqrt{2}\left(\cos\frac{31\pi}{20} + i\sin\frac{31\pi}{20}\right)$

$\sqrt{2}\left(\cos\frac{39\pi}{20} + i\sin\frac{39\pi}{20}\right)$

(b) $0.6420 + 1.2601i,$
$-1 + i,$
$-1.2601 - 0.6420i,$
$0.2212 - 1.3968i,$
$1.3968 - 0.2212i$

(c)



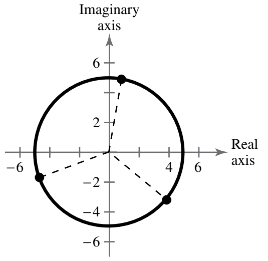
69. (a) $5\left(\cos\frac{4\pi}{9} + i\sin\frac{4\pi}{9}\right)$

$5\left(\cos\frac{10\pi}{9} + i\sin\frac{10\pi}{9}\right)$

$5\left(\cos\frac{16\pi}{9} + i\sin\frac{16\pi}{9}\right)$

(b) $0.8682 + 4.9240i,$
$-4.6985 - 1.7101i,$
$3.8302 - 3.2139i$

(c)

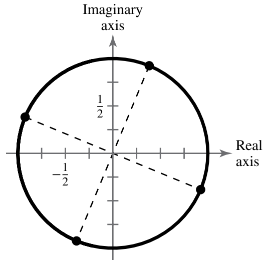


71. $\cos\frac{3\pi}{8} + i\sin\frac{3\pi}{8}$

$\cos\frac{7\pi}{8} + i\sin\frac{7\pi}{8}$

$\cos\frac{11\pi}{8} + i\sin\frac{11\pi}{8}$

$\cos\frac{15\pi}{8} + i\sin\frac{15\pi}{8}$



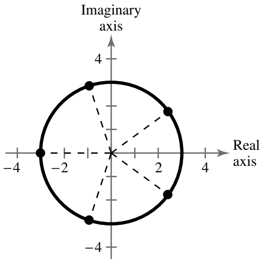
73. $3\left(\cos\frac{\pi}{5} + i\sin\frac{\pi}{5}\right)$

$3\left(\cos\frac{3\pi}{5} + i\sin\frac{3\pi}{5}\right)$

$3(\cos\pi + i\sin\pi)$

$3\left(\cos\frac{7\pi}{5} + i\sin\frac{7\pi}{5}\right)$

$3\left(\cos\frac{9\pi}{5} + i\sin\frac{9\pi}{5}\right)$



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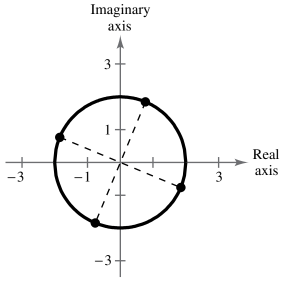
75. $2\left(\cos\frac{3\pi}{8} + i\sin\frac{3\pi}{8}\right)$

$2\left(\cos\frac{7\pi}{8} + i\sin\frac{7\pi}{8}\right)$

$2\left(\cos\frac{11\pi}{8} + i\sin\frac{11\pi}{8}\right)$

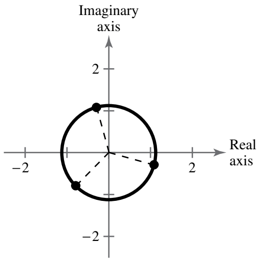
$2\left(\cos\frac{15\pi}{8} + i\sin\frac{15\pi}{8}\right)$



77. $\sqrt[6]{2}\left(\cos\frac{7\pi}{12} + i\sin\frac{7\pi}{12}\right)$

$\sqrt[6]{2}\left(\cos\frac{5\pi}{4} + i\sin\frac{5\pi}{4}\right)$

$\sqrt[6]{2}\left(\cos\frac{23\pi}{12} + i\sin\frac{23\pi}{12}\right)$



79. $E = 24(\cos 30° + i\sin 30°)$ volts, $E = 12\sqrt{3} + \frac{1}{2}i$ volts

81. False. They are equally spaced around the circle centered at the origin with radius $\sqrt[n]{r}$.

83. Answers will vary. **85.** The answer is $2\sqrt{3} + 2i$.

87. Yes **89.** No **91.** $y = 4 - x$

93. $y = \frac{5}{3}x - 2$ **95.** $-2, \frac{4}{3}$ **97.** $-\frac{1}{2} \pm \frac{\sqrt{3}}{2}i$

Review Exercises *(page 456)*

1. $C = 72°, b \approx 12.21, c \approx 12.36$

3. $A = 26°, a \approx 24.89, c \approx 56.23$

5. $C = 66°, a \approx 2.53, b \approx 9.11$

7. $B = 108°, a \approx 11.76, c \approx 21.49$

9. $A \approx 20.41°, C \approx 9.59°, a \approx 20.92$

11. $B \approx 39.48°, C \approx 65.52°, c \approx 48.24$

13. 19.1 **15.** 47.2 **17.** About 31.1 m

19. $A \approx 16.99°, B \approx 26.00°, C \approx 137.01°$

21. $A \approx 29.92°, B \approx 86.18°, C \approx 63.90°$

23. $A = 36°, C = 36°, b \approx 17.80$

25. $A \approx 45.76°, B \approx 91.24°, c \approx 21.42$

27. Law of Sines; no solution

29. Law of Cosines; $A \approx 28.62°, B \approx 33.56°, C \approx 117.82°$

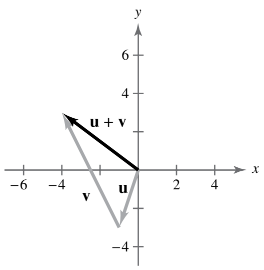
31. About 4.3 ft, about 12.6 ft

33. 7.64 **35.** 8.36

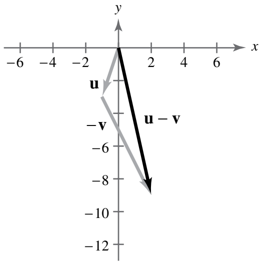
37. Not equivalent; **u** and **v** have a different direction.

39. $\langle 7, -7\rangle$; $7\sqrt{2}$

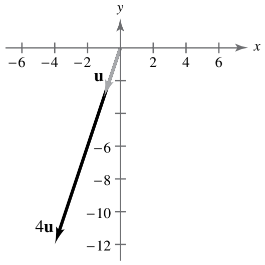
41. (a) $\langle -4, 3\rangle$



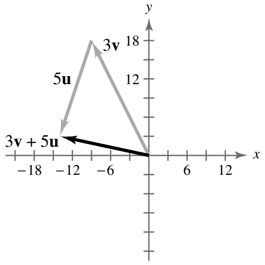
(b) $\langle 2, -9\rangle$



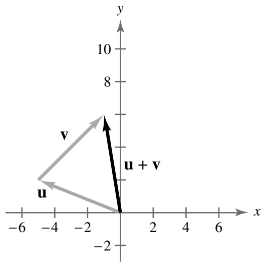
(c) $\langle -4, -12\rangle$



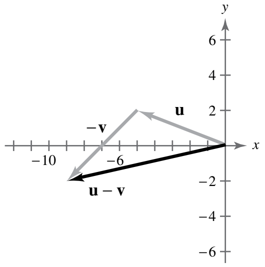
(d) $\langle -14, 3\rangle$



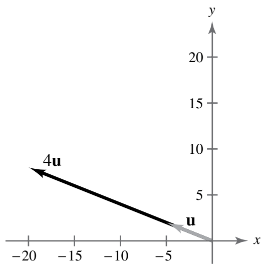
43. (a) $\langle -1, 6\rangle$



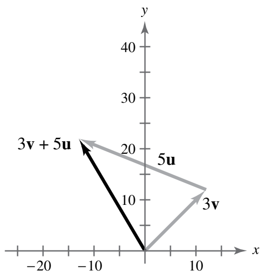
(b) $\langle -9, -2\rangle$



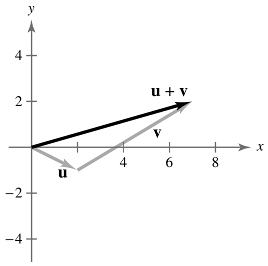
(c) $\langle -20, 8\rangle$



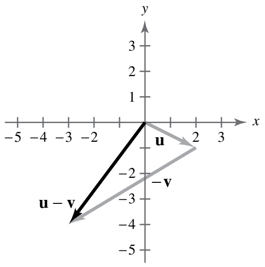
(d) $\langle -13, 22\rangle$



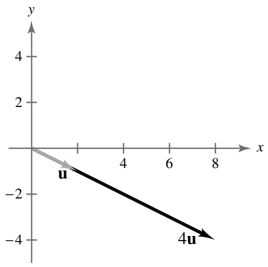
45. (a) $7\mathbf{i} + 2\mathbf{j}$



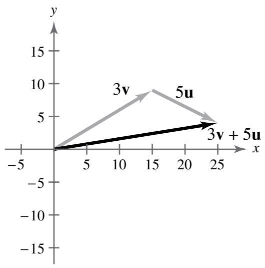
(b) $-3\mathbf{i} - 4\mathbf{j}$



(c) $8\mathbf{i} - 4\mathbf{j}$



(d) $25\mathbf{i} + 4\mathbf{j}$



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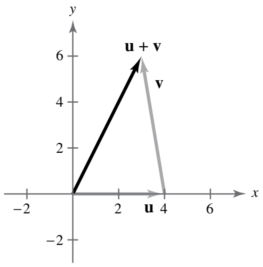
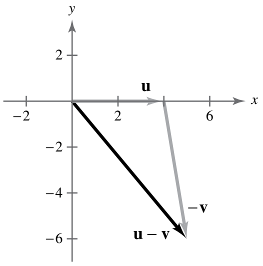
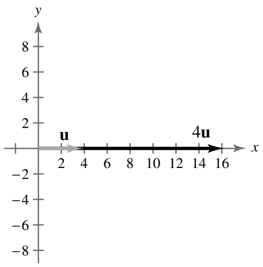
47. (a) $3\mathbf{i} + 6\mathbf{j}$



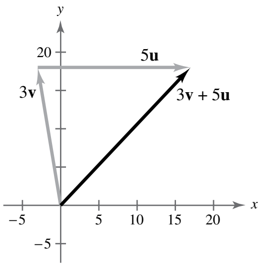
(b) $5\mathbf{i} - 6\mathbf{j}$



(c) $16\mathbf{i}$

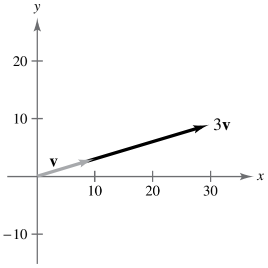


(d) $17\mathbf{i} + 18\mathbf{j}$

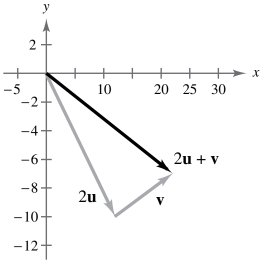


49. $-\mathbf{i} + 5\mathbf{j}$ **51.** $6\mathbf{i} + 4\mathbf{j}$

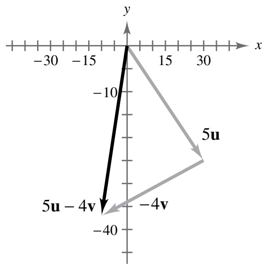
53. $\langle 30, 9\rangle$



55. $\langle 22, -7\rangle$



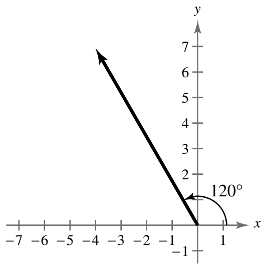
57. $\langle -10, -37\rangle$



59. $\|\mathbf{v}\| = \sqrt{41}$; $\theta \approx 38.7°$ **61.** $\|\mathbf{v}\| = 3\sqrt{2}$; $\theta = 225°$

63. $\|\mathbf{v}\| = 7$; $\theta = 60°$

65. $\mathbf{v} = \left\langle -4, 4\sqrt{3}\right\rangle$



67. About 50.5°; about 133.92 lb **69.** 45 **71.** −2

73. 40; scalar **75.** $4 - 2\sqrt{5}$; scalar

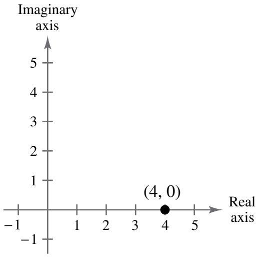
77. $\langle 72, -36\rangle$; vector **79.** 38; scalar **81.** About 160.5°

83. 165° **85.** Orthogonal

87. Not orthogonal **89.** $-\frac{13}{17}\langle 4, 1\rangle, \frac{16}{17}\langle -1, 4\rangle$

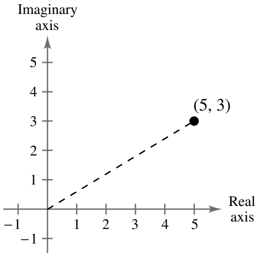
91. $\frac{5}{2}\langle -1, 1\rangle, \frac{9}{2}\langle 1, 1\rangle$ **93.** 48 **95.** 72,000 ft-lb

97.



4

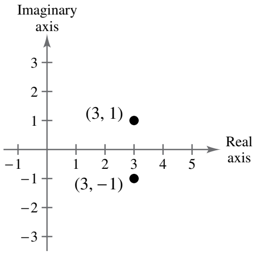
99.



$\sqrt{34}$

101. $3 + i$ **103.** $-2 + i$

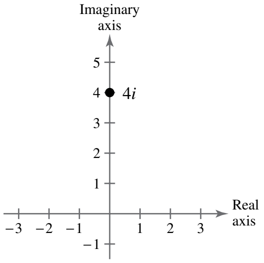
105.



$3 - i$

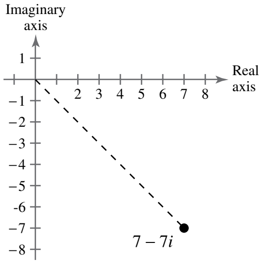
107. $\sqrt{10}$ **109.** $\left(\frac{5}{2}, 2\right)$

111.



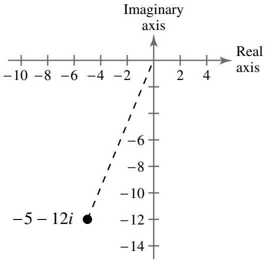
$4\left(\cos\frac{\pi}{2} + i\sin\frac{\pi}{2}\right)$

113.



$7\sqrt{2}\left(\cos\frac{7\pi}{4} + i\sin\frac{7\pi}{4}\right)$

115.



$13(\cos 4.32 + i\sin 4.32)$

117. $4\left(\cos\frac{7\pi}{12} + i\sin\frac{7\pi}{12}\right)$ **119.** $\frac{2}{3}(\cos 45° + i\sin 45°)$

121. $\frac{625}{2} + \frac{625\sqrt{3}}{2}i$ **123.** $2035 - 828i$

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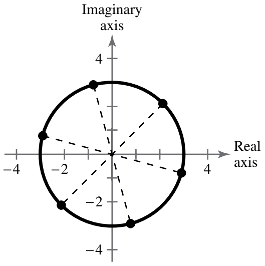
125. (a) $3\left(\cos\frac{\pi}{4}+i\sin\frac{\pi}{4}\right)$
$3\left(\cos\frac{7\pi}{12}+i\sin\frac{7\pi}{12}\right)$
$3\left(\cos\frac{11\pi}{12}+i\sin\frac{11\pi}{12}\right)$
$3\left(\cos\frac{5\pi}{4}+i\sin\frac{5\pi}{4}\right)$
$3\left(\cos\frac{19\pi}{12}+i\sin\frac{19\pi}{12}\right)$
$3\left(\cos\frac{23\pi}{12}+i\sin\frac{23\pi}{12}\right)$

(b) $\frac{3\sqrt{2}}{2}+\frac{3\sqrt{2}}{2}i$, $-0.7765+2.8978i$, $-2.8978+0.7765i$, $-\frac{3\sqrt{2}}{2}-\frac{3\sqrt{2}}{2}i$, $0.7765-2.8978i$, $2.8978-0.7765i$

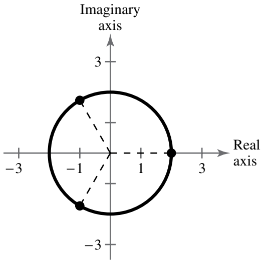
(c)



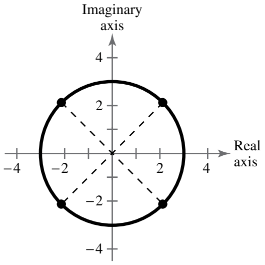
127. (a) $2(\cos 0+i\sin 0)$
$2\left(\cos\frac{2\pi}{3}+i\sin\frac{2\pi}{3}\right)$
$2\left(\cos\frac{4\pi}{3}+i\sin\frac{4\pi}{3}\right)$

(b) $2,\ -1+\sqrt{3}\,i,\ -1-\sqrt{3}\,i$

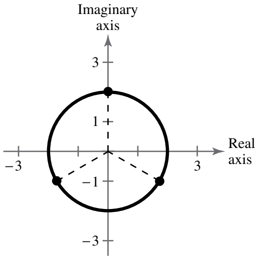
(c)



129. $3\left(\cos\frac{\pi}{4}+i\sin\frac{\pi}{4}\right)=\frac{3\sqrt{2}}{2}+\frac{3\sqrt{2}}{2}i$
$3\left(\cos\frac{3\pi}{4}+i\sin\frac{3\pi}{4}\right)=-\frac{3\sqrt{2}}{2}+\frac{3\sqrt{2}}{2}i$
$3\left(\cos\frac{5\pi}{4}+i\sin\frac{5\pi}{4}\right)=-\frac{3\sqrt{2}}{2}-\frac{3\sqrt{2}}{2}i$
$3\left(\cos\frac{7\pi}{4}+i\sin\frac{7\pi}{4}\right)=\frac{3\sqrt{2}}{2}-\frac{3\sqrt{2}}{2}i$



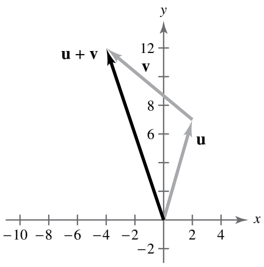
131. $2\left(\cos\frac{\pi}{2}+i\sin\frac{\pi}{2}\right)=2i$
$2\left(\cos\frac{7\pi}{6}+i\sin\frac{7\pi}{6}\right)=-\sqrt{3}-i$
$2\left(\cos\frac{11\pi}{6}+i\sin\frac{11\pi}{6}\right)=\sqrt{3}-i$



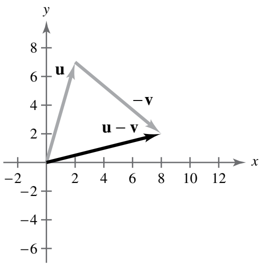
133. True. sin 90° is defined in the Law of Sines.
135. Direction and magnitude

Chapter Test *(page 459)*

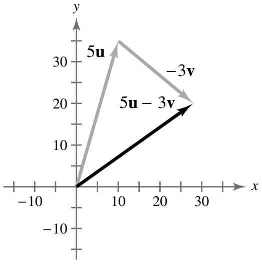
1. Law of Sines; $C=88°$, $b\approx 27.81$, $c\approx 29.98$
2. Law of Sines; $A=42°$, $b\approx 21.91$, $c\approx 10.95$
3. Law of Sines; Two solutions:
   $B\approx 29.12°$, $C\approx 126.88°$, $c\approx 22.03$
   $B\approx 150.88°$, $C\approx 5.12°$, $c\approx 2.46$
4. Law of Cosines; $A\approx 19.12°$, $B\approx 23.49°$, $C\approx 137.39°$
5. Law of Sines; No solution
6. Law of Cosines; $A\approx 21.90°$, $B\approx 37.10°$, $c\approx 78.15$
7. 2052.5 m^2 **8.** 606.3 mi; 29.1° **9.** $\langle 14,-23\rangle$
10. $\left\langle \frac{18\sqrt{34}}{17}, -\frac{30\sqrt{34}}{17}\right\rangle$
11. $\langle -4, 12\rangle$



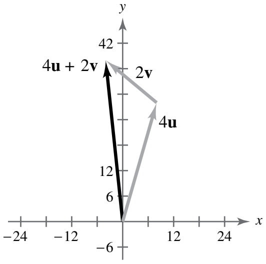
12. $\langle 8, 2\rangle$



13. $\langle 28, 20\rangle$



14. $\langle -4, 38\rangle$



15. 5 **16.** About 14.9°; about 250.15 lb **17.** 135°
18. Orthogonal **19.** $\frac{37}{26}\langle 5,1\rangle$; $\frac{29}{26}\langle -1,5\rangle$ **20.** About 104 lb
21. $4\sqrt{2}\left(\cos\frac{7\pi}{4}+i\sin\frac{7\pi}{4}\right)$ **22.** $-3+3\sqrt{3}\,i$
23. $-\frac{6561}{2}-\frac{6561\sqrt{3}}{2}i$ **24.** $5832i$ **25.** $4, -4, 4i, -4i$

CHAPTER 6

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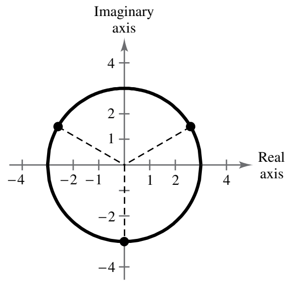
26. $3\left(\cos\frac{\pi}{6} + i\sin\frac{\pi}{6}\right)$

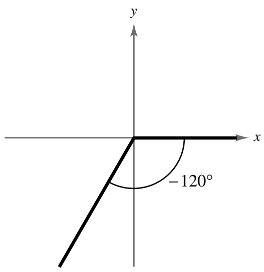
$3\left(\cos\frac{5\pi}{6} + i\sin\frac{5\pi}{6}\right)$

$3\left(\cos\frac{3\pi}{2} + i\sin\frac{3\pi}{2}\right)$



Cumulative Test for Chapters 4–6 *(page 460)*

1. (a)



(b) 240°

(c) $-\frac{2\pi}{3}$

(d) 60°

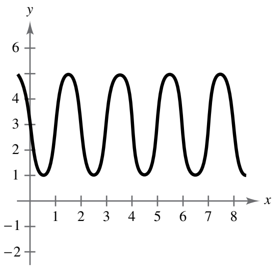
(e) $\sin(-120°) = -\frac{\sqrt{3}}{2}$ $\quad\csc(-120°) = -\frac{2\sqrt{3}}{3}$

$\cos(-120°) = -\frac{1}{2}$ $\quad\sec(-120°) = -2$

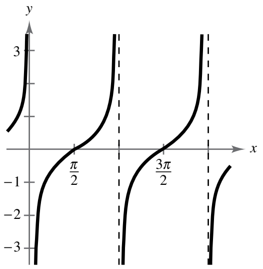
$\tan(-120°) = \sqrt{3}$ $\quad\cot(-120°) = \frac{\sqrt{3}}{3}$

2. $-83.079°$ **3.** $\frac{20}{29}$

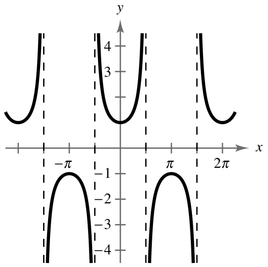
4.



5.

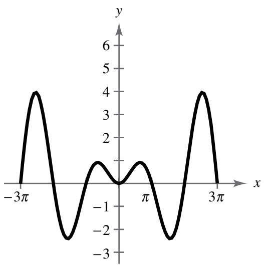


6.



7. $a = -3, b = \pi, c = 0$

8.



9. 4.9

10. $\frac{3}{4}$

11. $\sqrt{1 - 4x^2}$

12. 1

13. $2\tan\theta$

14–16. Answers will vary.

17. $\frac{\pi}{3}, \frac{\pi}{2}, \frac{3\pi}{2}, \frac{5\pi}{3}$

18. $\frac{\pi}{6}, \frac{5\pi}{6}, \frac{7\pi}{6}, \frac{11\pi}{6}$ **19.** $\frac{3\pi}{2}$ **20.** $\frac{16}{63}$ **21.** $\frac{4}{3}$

22. $\frac{\sqrt{5}}{5}$ **23.** $\frac{5}{2}\left(\sin\frac{5\pi}{2} - \sin\pi\right)$ **24.** $-2\sin 8x\sin x$

25. Law of Sines; $B \approx 26.39°$, $C \approx 123.61°$, $c \approx 14.99$

26. Law of Cosines; $B \approx 52.48°$, $C \approx 97.52°$, $a \approx 5.04$

27. Law of Sines; $B = 60°$, $a \approx 5.77$, $c \approx 11.55$

28. Law of Cosines; $A \approx 26.28°$, $B \approx 49.74°$, $C \approx 103.98°$

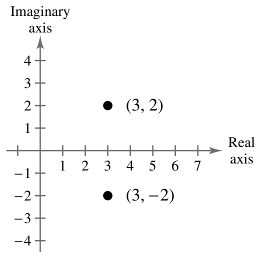
29. Law of Sines; $C = 109°$, $a \approx 14.96$, $b \approx 9.27$

30. Law of Cosines; $A \approx 6.88°$, $B \approx 93.12°$, $c \approx 9.86$

31. 41.48 in.^{2} **32.** 599.09 m^2 **33.** $7\mathbf{i} + 8\mathbf{j}$

34. $\left\langle \frac{\sqrt{2}}{2}, \frac{\sqrt{2}}{2} \right\rangle$ **35.** -5 **36.** $-\frac{1}{13}\langle 1, 5\rangle; \frac{21}{13}\langle 5, -1\rangle$

37.



$3 + 2i$

38. $2\sqrt{2}\left(\cos\frac{3\pi}{4} + i\sin\frac{3\pi}{4}\right)$ **39.** $24(\cos 150° + i\sin 150°)$

40. $\cos 0 + i\sin 0 = 1$

$\cos\frac{2\pi}{3} + i\sin\frac{2\pi}{3} = -\frac{1}{2} + \frac{\sqrt{3}}{2}i$

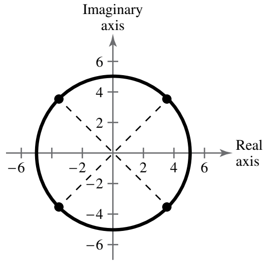
$\cos\frac{4\pi}{3} + i\sin\frac{4\pi}{3} = -\frac{1}{2} - \frac{\sqrt{3}}{2}i$

41. $\frac{5\sqrt{2}}{2} + \frac{5\sqrt{2}}{2}i$

$-\frac{5\sqrt{2}}{2} + \frac{5\sqrt{2}}{2}i$

$-\frac{5\sqrt{2}}{2} - \frac{5\sqrt{2}}{2}i$

$\frac{5\sqrt{2}}{2} - \frac{5\sqrt{2}}{2}i$



42. About 395.8 rad/min; about 8312.7 in./min

43. 42π yd$^2 \approx 131.95$ yd^2 **44.** 5 ft

45. About 22.6° **46.** $d = 4\cos\frac{\pi}{4}t$

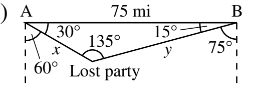
47. About 543.9 km/h; about 32.6°

48. 425 ft-lb

Problem Solving *(page 465)*

1. About 2.01 ft

3. (a)



(b) Station A: about 27.45 mi; Station B: about 53.03 mi

(c) About 11.03 mi; S 21.7° E

5. (a) (i) $\sqrt{2}$ (ii) $\sqrt{5}$ (iii) 1
(iv) 1 (v) 1 (vi) 1
(b) (i) 1 (ii) $3\sqrt{2}$ (iii) $\sqrt{13}$
(iv) 1 (v) 1 (vi) 1
(c) (i) $\frac{\sqrt{5}}{2}$ (ii) $\sqrt{13}$ (iii) $\frac{\sqrt{85}}{2}$
(iv) 1 (v) 1 (vi) 1
(d) (i) $2\sqrt{5}$ (ii) $5\sqrt{2}$ (iii) $5\sqrt{2}$
(iv) 1 (v) 1 (vi) 1

7. Proof

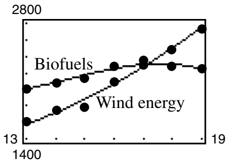
9. (a) $2(\cos 30° + i \sin 30°)$
$2(\cos 150° + i \sin 150°)$
$2(\cos 270° + i \sin 270°)$
(b) $3(\cos 45° + i \sin 45°)$
$3(\cos 135° + i \sin 135°)$
$3(\cos 225° + i \sin 225°)$
$3(\cos 315° + i \sin 315°)$

11. a; The angle between the vectors is acute.

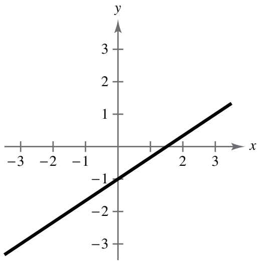
Chapter 7

Section 7.1 *(page 475)*

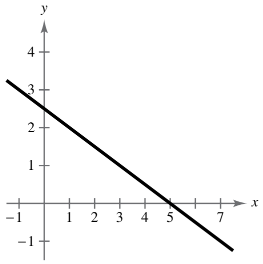
1. system; equations **3.** substitution
5. Break-even point
7. (a) No (b) No (c) No (d) Yes
9. (2, 2) **11.** (2, 6), (−1, 3)
13. (0, 0), (2, −4) **15.** (0, 1), (1, −1), (3, 1) **17.** (6, 4)
19. (−5, 2) **21.** $\left(\frac{1}{2}, 3\right)$ **23.** (1, 1) **25.** (2, 2.5)
27. $\left(\frac{20}{3}, \frac{40}{3}\right)$ **29.** No solution **31.** $\left(\frac{22}{5}, \frac{14}{5}\right)$
33. \$5500 at 2%; \$6500 at 6%
35. \$6000 at 2.8%; \$6000 at 3.8%
37. (−2, 4), (0, 0) **39.** No solution **41.** (6, 2)
43. $\left(-\frac{3}{2}, \frac{1}{2}\right)$ **45.** (2, 2), (4, 0) **47.** No solution
49. (4, 3), (−4, 3) **51.** (0, 1) **53.** (5.31, −0.54)
55. (1, 2) **57.** No solution **59.** (0.287, 1.751)
61. $\left(\frac{1}{2}, 2\right), \left(-4, -\frac{1}{4}\right)$ **63.** 293 units
65. (a) 344 units (b) 2495 units
67. (a) Biofuels:
$C_1 = -3.250t^3 + 141.96t^2 - 1978.3t + 10{,}874$
Wind energy: $C_2 = 11.20t^2 - 162.5t + 1797$
(b)



(c) (17.16, 2306.34); The average rate of consumption of biofuels and wind energy were approximately equal around 2017.
(d) Answers will vary.
69. 12 m × 16 m
71. False. You can solve for either variable in either equation and then back-substitute.
73. *Sample answer:* After substituting, the resulting equation may be a contradiction or have imaginary solutions.
75. Answers will vary. *Sample answer:*
(a) $y = x + 1$
(b) $y = 2x - 1$
(c) $y = x - 1$
77. (a)–(b) Answers will vary. **79.** $20x + 4y = -4$
81. $6x - 12y = 42$ **83.** $2x - 5y = -38$ **85.** 2
87. $-\frac{1}{2}$ **89.** 3 **91.** −1
93.

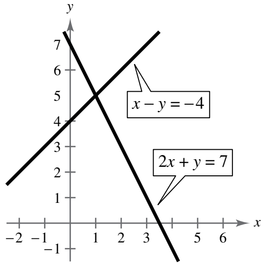


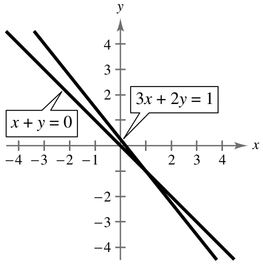
95.



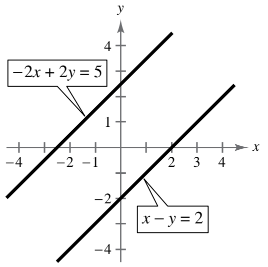
Section 7.2 *(page 486)*

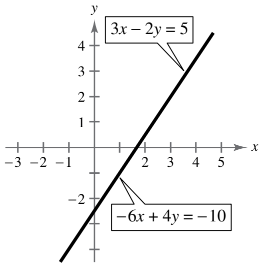
1. elimination **3.** equilibrium point **5.** Inconsistent
7. (1, 5) **9.** (1, −1)





11. No solution **13.** $\left(a, \frac{3}{2}a - \frac{5}{2}\right)$





15. (4, 1) **17.** $\left(\frac{3}{2}, -\frac{1}{2}\right)$ **19.** $\left(-3, \frac{5}{3}\right)$ **21.** (4, −1)
23. $\left(-\frac{6}{35}, \frac{43}{35}\right)$ **25.** (101, 96) **27.** No solution
29. Infinitely many solutions: $\left(a, -\frac{1}{2} + \frac{5}{6}a\right)$
31. (5, −2) **33.** a; infinitely many solutions; consistent
35. d; no solutions; inconsistent **37.** (4, 1)
39. (10, 5) **41.** (19, −55) **43.** 550 mi/h; 50 mi/h
45. Cheeseburger: 570 calories; fries: 320 calories
47. (240, 404) **49.** \$18,000
51. (a) $y = -44.21x + 89.53$ (b) 12 units
53. $y = 0.97x + 2.1$
55. (a) $y = 14x + 19$ (b) 41.4 bushels/acre
57. False. Two lines that coincide have infinitely many points of intersection.
59. $k = -4$ **61.** Answers will vary.
63. (39,600, 398). It is necessary to change the scale on the axes to see the point of intersection.
65. No. Two lines will intersect only once or will coincide, and if they coincide the system will have infinitely many solutions.
67. $u = 1, v = -\tan x$ **69.** −1 **71.** $-1, \frac{5}{2}$
73. ±1, ±3 **75.** $y = \frac{11}{4}x - \frac{19}{4}$ **77.** $y = -\frac{3}{2}x + 5$

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79. $6 \pm 2\sqrt{3}$ **81.** $\pm 1, \frac{7}{6}$

Section 7.3 *(page 498)*

1. row-echelon **3.** Gaussian

5. Interchange two equations; multiply one of the equations by a nonzero constant, add a multiple of one equation to another equation to replace the latter equation.

7. (a) No (b) No (c) No (d) Yes

9. (a) No (b) No (c) Yes (d) No

11. $(-13, -10, 8)$ **13.** $(3, 10, 2)$ **15.** $\left(\frac{11}{4}, 7, 11\right)$

17. $\begin{cases} x - 2y + 3z = 5 \\ y - 2z = 9 \\ 2x - 3z = 0 \end{cases}$

First step in putting the system in row-echelon form.

19. $(-2, 2)$ **21.** $(4, 3)$ **23.** $(4, 1, 2)$ **25.** $\left(1, \frac{1}{2}, -3\right)$

27. No solution **29.** $\left(\frac{1}{8}, -\frac{5}{8}, -\frac{1}{2}\right)$ **31.** $(0, 0, 0)$

33. No solution **35.** $(-a + 3, a + 1, a)$

37. $(-3a + 10, 5a - 7, a)$ **39.** $(1, 1, 1, 1)$

41. $(2a, 21a - 1, 8a)$ **43.** $\left(-\frac{3}{2}a + \frac{1}{2}, -\frac{2}{3}a + 1, a\right)$

45. $s = -16t^2 + 144$ **47.** $s = -16t^2 - 32t + 400$

49. $y = \frac{1}{2}x^2 - 2x$ **51.** $y = x^2 - 6x + 8$

53. $y = 4x^2 - 2x + 1$ **55.** $x^2 + y^2 - 10x = 0$

57. $x^2 + y^2 + 6x - 8y = 0$

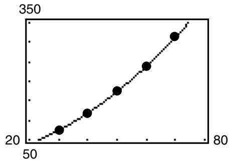
59. Brand X = 4 lb
Brand Y = 9 lb
Brand Z = 9 lb

61. $x = 60°, y = 67°, z = 53°$ **63.** $I_1 = 1, I_2 = 2, I_3 = 1$

65. $y = x^2 - x$

67. (a) $y = 0.0514x^2 + 0.8771x + 1.8857$

(b)



The model fits the data well.

(c) About 356 ft

69. $x = \pm\frac{\sqrt{2}}{2}, y = \frac{1}{2}, \lambda = 1$ or $x = 0, y = 0, \lambda = 0$

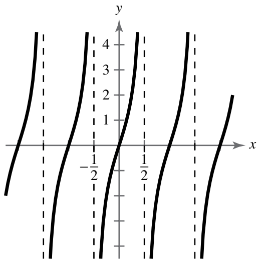
71. False. See Example 6 on page 495.

73. Answers will vary. **75–77.** Answers will vary.

79. $-\frac{x-2}{5}, x \neq -4$ **81.** $\frac{3(x+1)(x+2)}{x^3 - 2x^2 - x - 2}$

83. $-3x + 1, x \neq 6$ **85.** $x^2 + x + 2 + \frac{13}{x-3}$

87.



Section 7.4 *(page 508)*

1. improper **3.** Two

5. $\frac{A}{x} + \frac{B}{x-2}$ **7.** $\frac{A}{x+2} + \frac{B}{(x+2)^2} + \frac{C}{(x+2)^3} + \frac{D}{(x+2)^4}$

9. $\frac{A}{x} + \frac{B}{x^2} + \frac{Cx + D}{x^2 + 3} + \frac{Ex + F}{(x^2 + 3)^2}$ **11.** $\frac{1}{x} - \frac{1}{x+1}$

13. $\frac{1}{x-1} - \frac{1}{x+2}$ **15.** $\frac{1}{2}\left(\frac{1}{x-1} - \frac{1}{x+1}\right)$

17. $-\frac{3}{x} - \frac{1}{x+2} + \frac{5}{x-2}$ **19.** $\frac{3}{x-3} + \frac{9}{(x-3)^2}$

21. $\frac{3}{x} - \frac{1}{x^2} + \frac{1}{x+1}$ **23.** $\frac{2}{3}\left(\frac{1}{x-1} - \frac{x-1}{x^2+x+1}\right)$

25. $-\frac{1}{x-1} + \frac{x+2}{x^2-2}$ **27.** $\frac{1}{8}\left(\frac{1}{2x+1} + \frac{1}{2x-1} - \frac{4x}{4x^2+1}\right)$

29. $\frac{1}{x+1} + \frac{2}{x^2 - 2x + 3}$ **31.** $\frac{2}{x^2+4} + \frac{x}{(x^2+4)^2}$

33. $\frac{2}{x} - \frac{3}{x^2} - \frac{2x-3}{x^2+2} - \frac{4x-6}{(x^2+2)^2}$ **35.** $1 - \frac{2x+1}{x^2+x+1}$

37. $2x - 7 + \frac{17}{x+2} + \frac{1}{x+1}$

39. $x + 3 + \frac{6}{x-1} + \frac{4}{(x-1)^2} + \frac{1}{(x-1)^3}$

41. $x + \frac{2}{x} + \frac{1}{x+1} + \frac{3}{(x+1)^2}$ **43.** $\frac{3}{2x-1} - \frac{2}{x+1}$

45. $\frac{2}{x} + \frac{4}{x+1} - \frac{3}{x-1}$ **47.** $\frac{1}{x^2+2} + \frac{x}{(x^2+2)^2}$

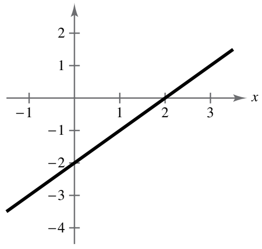
49. $2x + \frac{1}{2}\left(\frac{3}{x-4} - \frac{1}{x+2}\right)$ **51.** $\frac{60}{100-p} - \frac{60}{100+p}$

53. True. The expression is an improper rational expression.

55. The expression is improper, so first divide the denominator into the numerator to obtain $1 + \frac{x+1}{x^2 - x}$.

57. Answers will vary. *Sample answer:* You can substitute any convenient values of x that will help determine the constants. You can also find the basic equation, expand it, then equate coefficients of like terms.

59.



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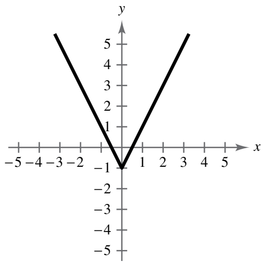

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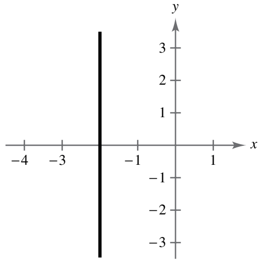

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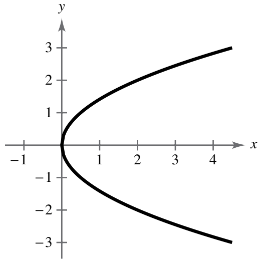

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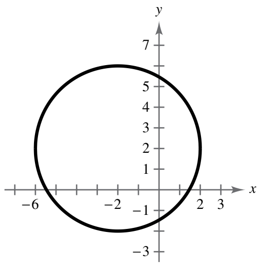
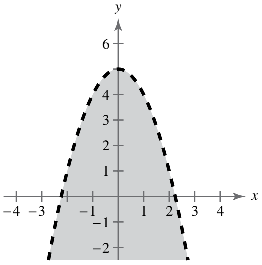


69. (a) Yes (b) Yes **71.** (a) Yes (b) No

Section 7.5 *(page 517)*

1. graph
3. The graph of an inequality with a $<$ sign does not include the points on the graph of the corresponding equation, and the graph of an inequality with a $\leq$ sign does include the points on the graph of the corresponding equation.

5.



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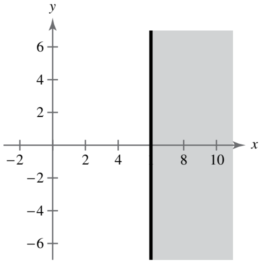

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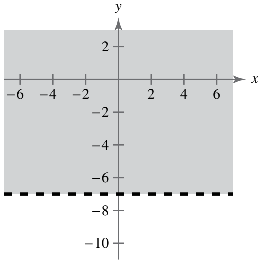

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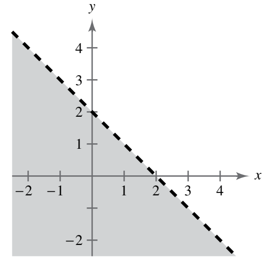

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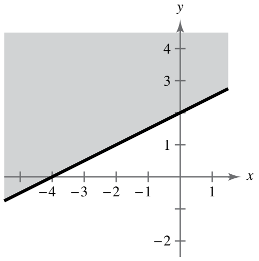

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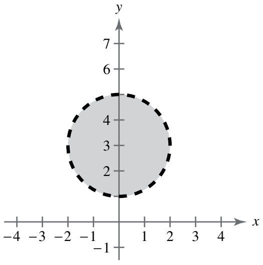

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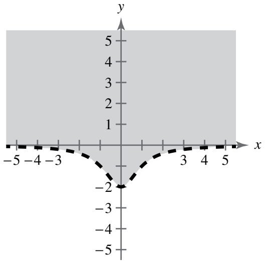

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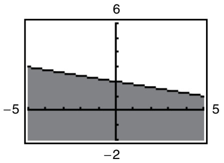

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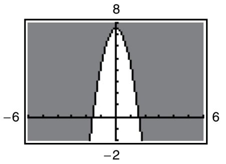

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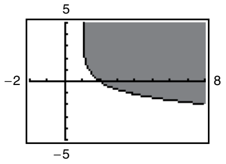

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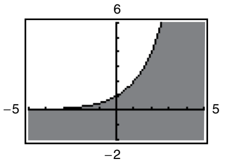

27. $y < 5x + 5$ **29.** $y \geq x^2 - 4$

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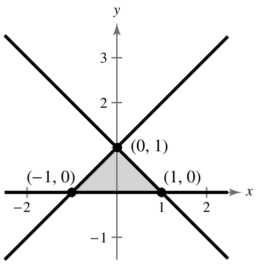

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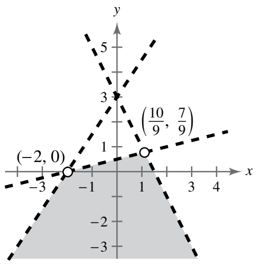

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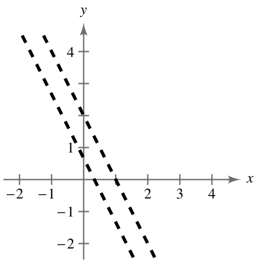
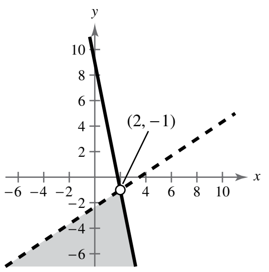


No solution

37.



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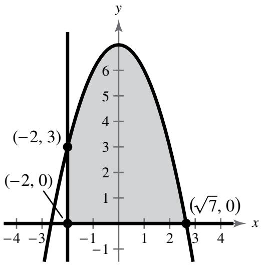

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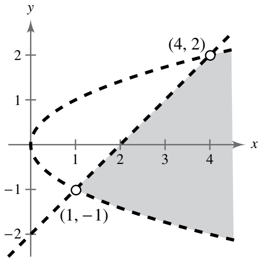

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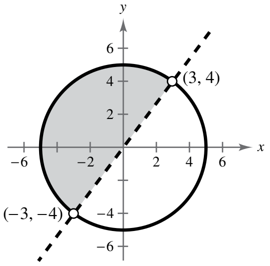

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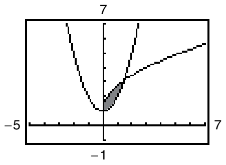

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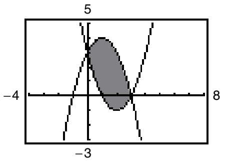
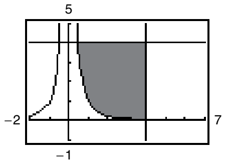


49.



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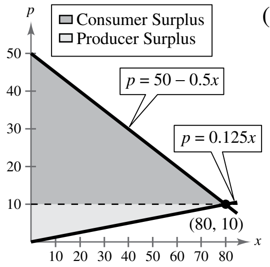
51. $\begin{cases} x \ge 0 \\ y \ge 0 \\ y \le 6 - x \end{cases}$ **53.** $\begin{cases} x \ge 0 \\ y \ge 0 \\ x^2 + y^2 < 64 \end{cases}$

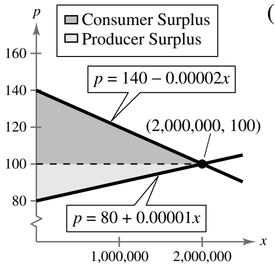
55. $\begin{cases} x \ge 4 \\ x \le 9 \\ y \ge 3 \\ y \le 9 \end{cases}$ **57.** $\begin{cases} y \ge 0 \\ y \le 5x \\ y \le -x + 6 \end{cases}$

59. (a)



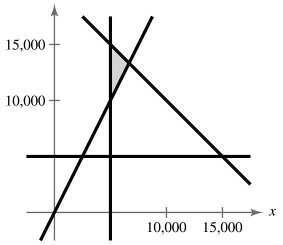
(b) Consumer surplus: \$1600
Producer surplus: \$400

61. (a)

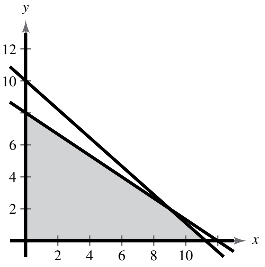


(b) Consumer surplus: \$40,000,000
Producer surplus: \$20,000,000

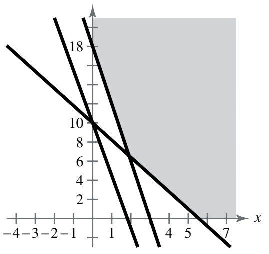
63. $\begin{cases} x + y \le 20{,}000 \\ y \ge 2x \\ x \ge 5{,}000 \\ y \ge 5{,}000 \end{cases}$



65. $\begin{cases} x + \frac{3}{2}y \le 12 \\ \frac{4}{3}x + \frac{3}{2}y \le 15 \\ x \ge 0 \\ y \ge 0 \end{cases}$

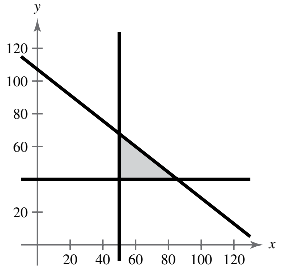


67. (a) $\begin{cases} 180x + 100y \ge 1000 \\ 6x + y \ge 18 \\ 220x + 40y \ge 400 \\ x \ge 0 \\ y \ge 0 \end{cases}$



(b) Answers will vary.

69. (a) $\begin{cases} x \ge 50 \\ y \ge 40 \\ 55x + 70y \le 7500 \end{cases}$



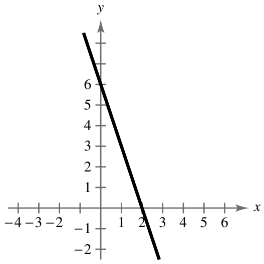
(b) Answers will vary.

71. True. The figure is a rectangle with a length of 9 units and a width of 11 units.

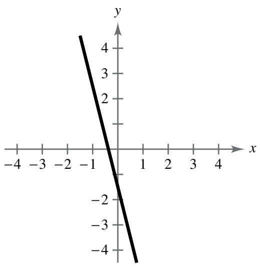
73. False. The solution region lies between the parallel lines $y = x/3 - 8/3$ and $y = x/3 + 5/3$.

75. Test a point on each side of the line.

77. Slope: -3
y-intercept: $(0, 6)$



79. Slope: -4
y-intercept: $\left(0, -\frac{3}{2}\right)$



81. Relative minimum: $(-1.25, -3.13)$

83. Relative minimum: $(-0.67, -0.38)$

85. $\sin 15^\circ = \dfrac{\sqrt{2 - \sqrt{3}}}{2}$

$\cos 15^\circ = \dfrac{\sqrt{2 + \sqrt{3}}}{2}$

$\tan 15^\circ = 2 - \sqrt{3}$

87. $\sin\left(-\dfrac{5\pi}{12}\right) = -\dfrac{\sqrt{2} + \sqrt{6}}{4}$

$\cos\left(-\dfrac{5\pi}{12}\right) = \dfrac{\sqrt{6} - \sqrt{2}}{4}$

$\tan\left(-\dfrac{5\pi}{12}\right) = -2 - \sqrt{3}$

89. $\sin(-22^\circ\, 30') = -\dfrac{\sqrt{2 - \sqrt{2}}}{2}$

$\cos(-22^\circ\, 30') = \dfrac{\sqrt{2 + \sqrt{2}}}{2}$

$\tan(-22^\circ\, 30') = -\left(\sqrt{2} - 1\right)$

Section 7.6 *(page 526)*

1. objective

3. Find the points of intersection of the graphs of the equations corresponding to adjacent constraints.

5. Minimum at $(0, 0)$: 0
Maximum at $(5, 0)$: 20

7. Minimum at $(1, 0)$: 2
Maximum at $(3, 4)$: 26

9. Minimum at $(0, 20)$: 140
Maximum at $(60, 20)$: 740

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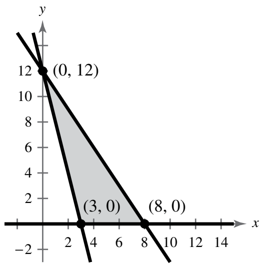
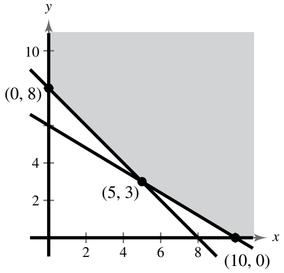
11.



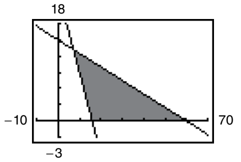
Minimum at (3, 0): 9
Maximum at any point on the line segment connecting (0, 12) and (8, 0): 24

13.



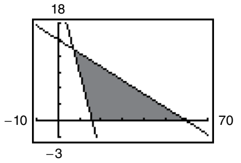
Minimum at (5, 3): 35
No maximum

15.



Minimum at (7.2, 13.2): 34.8
Maximum at (60, 0): 180

17.



Minimum at (7.2, 13.2): 7.2
Maximum at (60, 0): 60

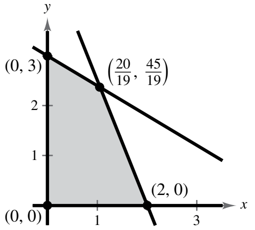
19. Minimum at (0, 0): 0
Maximum at (0, 5): 25

21. Minimum at (0, 0): 0
Maximum at $\left(\frac{22}{3}, \frac{19}{6}\right)$: $\frac{271}{6}$

23. Minimum at (4, 3): 10
No maximum

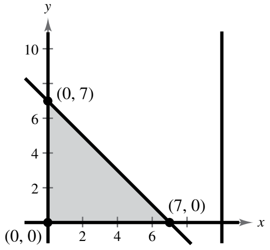
25. No minimum
Maximum at (12, 5): 7

27.



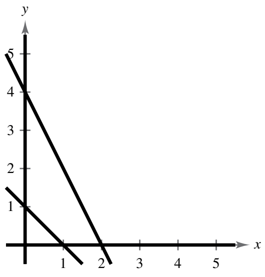
The maximum, 5, occurs at any point on the line segment connecting (2, 0) and $\left(\frac{20}{19}, \frac{45}{19}\right)$. Minimum at (0, 0): 0

29.



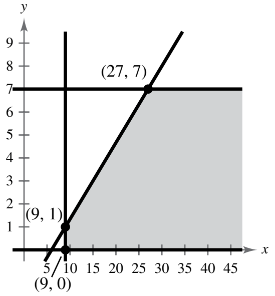
The constraint $x \leq 10$ is extraneous. Minimum at (7, 0): −7; maximum at (0, 7): 14

31.



The feasible set is empty.

33.



The solution region is unbounded.
Minimum at (9, 0): 9
No maximum

35. 13 audits
0 tax returns
Optimal revenue: $20,800

37. 2 bottles of brand X
5 bottles of brand Y

39. 400 units of model X
1200 units of model Y
Optimal profit: $570,000

41. True. The objective function has a maximum value at any point on the line segment connecting the two vertices.

43. The solution region is unbounded and there is no maximum value.

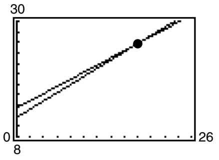
45. $-\frac{3}{5}$ **47.** (−7, −6, −4)

49. $\left(\frac{7}{3}, \frac{8}{3}, -\frac{1}{3}\right)$ **51.** (1, 1, 1, 1)

Review Exercises *(page 531)*

1. (1, 1) **3.** $\left(\frac{3}{2}, 5\right)$ **5.** (0.25, 0.625) **7.** (5, 4)
9. (0, 0), (2, 8), (−2, 8) **11.** (4, −2)
13. (1.41, −0.66), (−1.41, 10.66) **15.** (0, −2)
17. No solution

19.



The BMI for males exceeds the BMI for females after age 18.

21. 16 ft × 18 ft **23.** $\left(\frac{5}{2}, 3\right)$ **25.** (0, 0)
27. $\left(\frac{8}{5}a + \frac{14}{5}, a\right)$ **29.** d, one solution, consistent
31. b, no solution, inconsistent
33. (100,000, 23) **35.** (2, −4, −5)
37. (−6, 7, 10) **39.** $\left(\frac{24}{5}, \frac{22}{5}, -\frac{8}{5}\right)$ **41.** $\left(-\frac{3}{4}, 0, -\frac{5}{4}\right)$
43. $(a - 4, a - 3, a)$ **45.** $y = 2x^2 + x - 5$
47. $x^2 + y^2 - 4x + 4y - 1 = 0$

49. 10 gal of spray X
5 gal of spray Y
12 gal of spray Z

51. $16,000 at 7%
$13,000 at 9%
$11,000 at 11%

53. $s = -16t^2 + 150$ **55.** $\frac{A}{x} + \frac{B}{x + 20}$

57. $\frac{A}{x} + \frac{B}{x^2} + \frac{C}{x - 5}$ **59.** $\frac{3}{x + 2} - \frac{4}{x + 4}$

61. $1 - \frac{25}{8(x + 5)} + \frac{9}{8(x - 3)}$ **63.** $\frac{1}{2}\left(\frac{3}{x - 1} - \frac{x - 3}{x^2 + 1}\right)$

65. $\frac{3}{x^2 + 1} + \frac{4x - 3}{(x^2 + 1)^2}$

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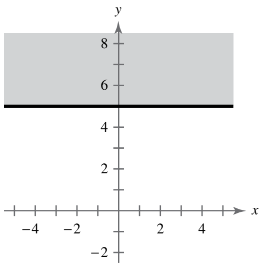
67.



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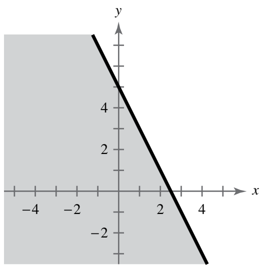

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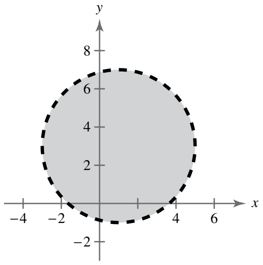

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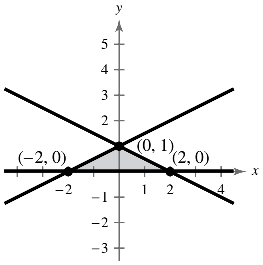

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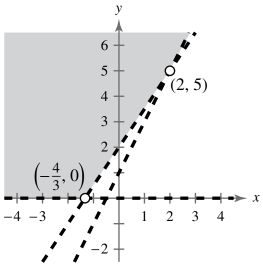

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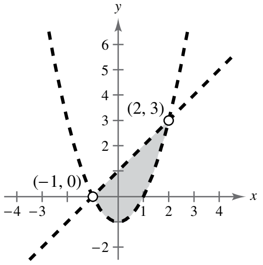

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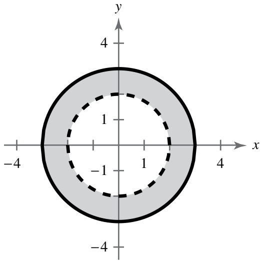
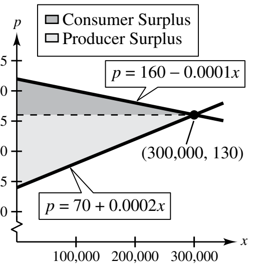


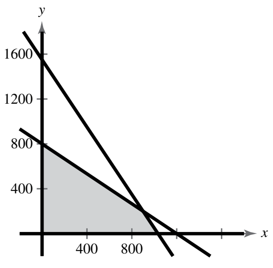
81. $\begin{cases} x \geq 3 \\ x \leq 7 \\ y \geq 1 \\ y \leq 10 \end{cases}$

83. (a)

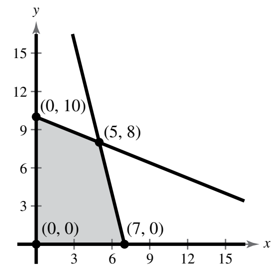


(b) Consumer surplus: \$4,500,000
Producer surplus: \$9,000,000

85. $\begin{cases} 20x + 30y \leq 24{,}000 \\ 12x + 8y \leq 12{,}400 \\ x \geq 0 \\ y \geq 0 \end{cases}$

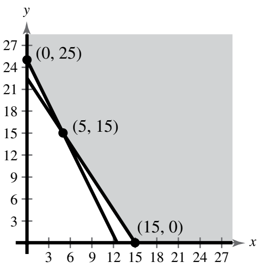


87.



Minimum at $(0, 0)$: 0
Maximum at $(5, 8)$: 47

89.



Minimum at $(15, 0)$: 26.25
No maximum

91. 72 haircuts
0 permanents
Optimal revenue: \$1800

93. True. The nonparallel sides of the trapezoid are equal in length.

95. $\begin{cases} 4x + y = -22 \\ \frac{1}{2}x + y = 6 \end{cases}$

97. $\begin{cases} 3x + y = 7 \\ -6x + 3y = 1 \end{cases}$

99. $\begin{cases} x + y + z = 6 \\ x + y - z = 0 \\ x - y - z = 2 \end{cases}$

101. $\begin{cases} 2x + 2y - 3z = 7 \\ x - 2y + z = 4 \\ -x + 4y - z = -1 \end{cases}$

103. An inconsistent system of linear equations has no solution.

Chapter Test *(page 535)*

1. $(-4, -5)$ **2.** $(0, -1), (1, 0), (2, 1)$ **3.** $(8, 4), (2, -2)$

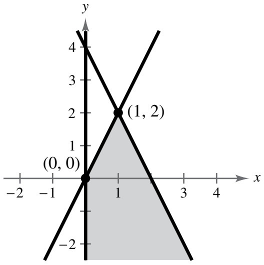
4. $(4, 2)$ **5.** $(-3, 0), (2, 5)$ **6.** $(1, 4), (0.034, 0.619)$

7. $(-2, -5)$ **8.** $(10, -3)$ **9.** $(2, -3, 1)$

10. No solution **11.** $-\dfrac{1}{x+1} + \dfrac{3}{x-2}$ **12.** $\dfrac{2}{x^2} + \dfrac{3}{2-x}$

13. $x - \dfrac{5}{x} + \dfrac{3}{x+1} + \dfrac{3}{x-1}$ **14.** $-\dfrac{2}{x} + \dfrac{3x}{x^2+2}$

15.



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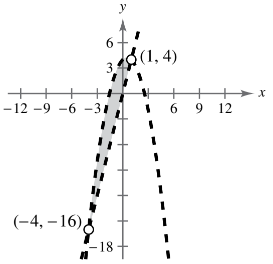
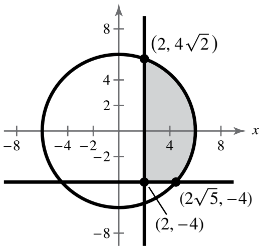


17.



18. Minimum at $(0, 0)$: 0
Maximum at $(12, 0)$: 240

19. \$24,000 in 4% fund
\$26,000 in 5.5% fund

20. $y = -\frac{1}{2}x^2 + x + 6$

21. 900 units of model I
4400 units of model II
Optimal profit: \$203,000

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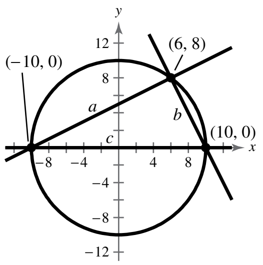
Problem Solving *(page 537)*

1.



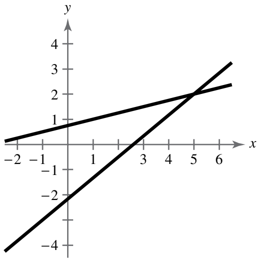
$a = 8\sqrt{5}, b = 4\sqrt{5}, c = 20$

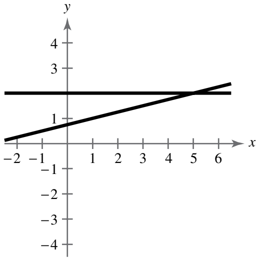
$(8\sqrt{5})^2 + (4\sqrt{5})^2 = 20^2$

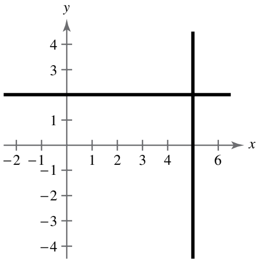
So, the triangle is a right triangle.

3. $ad \neq bc$

5. (a)



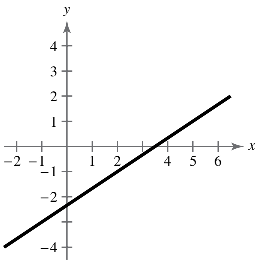




(5, 2)

Answers will vary.

(b)



$\left(\frac{3}{2}a + \frac{7}{2}, a\right)$

Answers will vary.

7. 10.1 ft; About 252.7 ft **9.** \$12.00

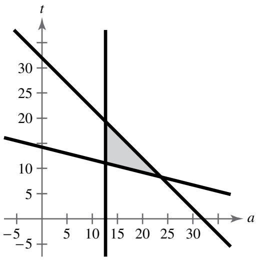
11. (a) $(3, -4)$ (b) $\left(\dfrac{2}{-a+5}, \dfrac{1}{4a-1}, \dfrac{1}{a}\right)$

13. (a) $\left(\dfrac{-5a+16}{6}, \dfrac{5a-16}{6}, a\right)$

(b) $\left(\dfrac{-11a+36}{14}, \dfrac{13a-40}{14}, a\right)$

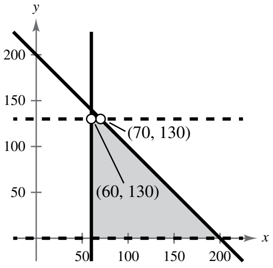
(c) $(-a+3, a-3, a)$ (d) Infinitely many

15. $\begin{cases} a + t \leq 32 \\ 0.15a \geq 1.9 \\ 193a + 772t \geq 11{,}000 \end{cases}$



17. (a) $\begin{cases} 0 < y < 130 \\ x \geq 60 \\ x + y \leq 200 \end{cases}$

(b)



(c) No. The point (90, 120) is not in the solution region.

(d) *Sample answer:* LDL/VLDL: 135 mg/dL; HDL: 65 mg/dL

(e) *Sample answer:* (75, 90); $\frac{165}{75} = 2.2 < 4$

Chapter 8

Section 8.1 *(page 549)*

1. row-equivalent

3. *Sample answer:* 2 × 2 square matrix

$$\begin{bmatrix} -2 & 3 \\ 6 & 7 \end{bmatrix}$$

5. 1 × 2 **7.** 3 × 1 **9.** 2 × 2 **11.** 3 × 3

13. $\begin{bmatrix} 2 & -1 & \vdots & 7 \\ 1 & 1 & \vdots & 2 \end{bmatrix}$ **15.** $\begin{bmatrix} 1 & -1 & 2 & \vdots & 2 \\ 4 & -3 & 1 & \vdots & -1 \\ 2 & 1 & 0 & \vdots & 0 \end{bmatrix}$

17. $\begin{bmatrix} 3 & -5 & 2 & \vdots & 12 \\ 12 & 0 & -7 & \vdots & 10 \end{bmatrix}$

19. $\begin{cases} x + y = 3 \\ 5x - 3y = -1 \end{cases}$ **21.** $\begin{cases} 2x + 5z = -12 \\ y - 2z = 7 \\ 6x + 3y = 2 \end{cases}$

23. $\begin{cases} 9x + 12y + 3z = 0 \\ -2x + 18y + 5z + 2w = 10 \\ x + 7y - 8z = -4 \\ 3x + 2z = -10 \end{cases}$

25. Add 5 times Row 2 to Row 1.

27. Interchange Row 1 and Row 2.
Add 4 times new Row 1 to Row 3.

29. $\begin{bmatrix} 1 & 2 & \frac{8}{3} \\ 4 & -3 & 6 \end{bmatrix}$ **31.** $\begin{bmatrix} 1 & 1 & 1 \\ 0 & -7 & -1 \end{bmatrix}$

33. $\begin{bmatrix} 1 & 0 & 14 & -11 \\ 0 & 1 & -2 & 2 \\ 0 & 0 & 1 & -7 \end{bmatrix}$

35. $\begin{bmatrix} 1 & 1 & 4 & -1 \\ 0 & 5 & -2 & 6 \\ 0 & 3 & 20 & 4 \end{bmatrix}; \begin{bmatrix} 1 & 1 & 4 & -1 \\ 0 & 1 & -\frac{2}{5} & \frac{6}{5} \\ 0 & 3 & 20 & 4 \end{bmatrix}$

37. (a) (i) $\begin{bmatrix} 3 & 0 & \vdots & -6 \\ 6 & -4 & \vdots & -28 \end{bmatrix}$

(ii) $\begin{bmatrix} 3 & 0 & \vdots & -6 \\ 0 & -4 & \vdots & -16 \end{bmatrix}$

(iii) $\begin{bmatrix} 3 & 0 & \vdots & -6 \\ 0 & 1 & \vdots & 4 \end{bmatrix}$

(iv) $\begin{bmatrix} 1 & 0 & \vdots & -2 \\ 0 & 1 & \vdots & 4 \end{bmatrix}$

(b) $\begin{cases} -3x + 4y = 22 \\ 6x - 4y = -28 \end{cases}$

Solution: $(-2, 4)$

(c) Answers will vary.

39. Reduced row-echelon form **41.** Not in row-echelon form

43–47. *Sample answers:*

43. $\begin{bmatrix} 1 & 1 & 0 & 5 \\ 0 & 1 & 2 & 0 \\ 0 & 0 & 1 & -1 \end{bmatrix}$ **45.** $\begin{bmatrix} 1 & -1 & -1 & 1 \\ 0 & 1 & 6 & 3 \\ 0 & 0 & 0 & 0 \end{bmatrix}$

47. $\begin{bmatrix} 0 & 2 & \frac{11}{4} & -\frac{7}{2} \\ 0 & 1 & 1 & -\frac{8}{3} \\ 0 & 0 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix}$ **49.** $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{bmatrix}$

51. $\begin{bmatrix} 1 & 0 & 3 & 16 \\ 0 & 1 & 2 & 12 \end{bmatrix}$

53. $\begin{cases} x - 2y = 4 \\ y = -1 \end{cases}$ $(2, -1)$

55. $\begin{cases} x - y + 2z = 4 \\ y - z = 2 \\ z = -2 \end{cases}$ $(8, 0, -2)$

57. $(-3, 5)$ **59.** $(-5, 6)$ **61.** $(-4, -3, 6)$

63. No solution **65.** $(3, -2, 5, 0)$ **67.** $(3, -4)$

69. $(-1, -4)$ **71.** $(4, -3, 2)$ **73.** $(5a + 4, -3a + 2, a)$

75. $(7, -3, 4)$ **77.** $(0, 2 - 4a, a)$ **79.** $(1, 0, 4, -2)$

81. $(-2a, a, a, 0)$ **83.** $f(x) = -x^2 + x + 1$

85. $f(x) = -9x^2 - 5x + 11$

87. \$1,200,000 at 8%
\$200,000 at 9%
\$600,000 at 12%

89. $y = 7.5t + 28$; About 141 cases; Yes, because the data values increase in a linear pattern.

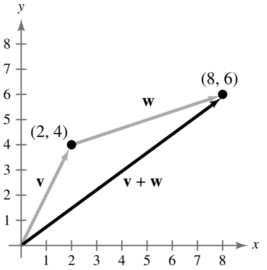
91. False. It is a 2 × 4 matrix.

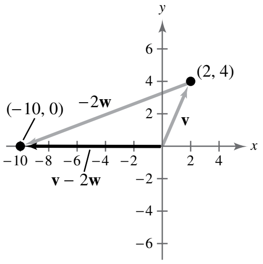
93. The matrix is in row-echelon form, not reduced row-echelon form.

95. -5 **97.** $a = -3, b = 8$ **99.** $a = 8, b = 4$

101. $x = \dfrac{b - a}{3}$ **103.** $x = 6b - a$

105. $\mathbf{u} = \langle 8, 6 \rangle$ **107.** $\mathbf{u} = \langle -10, 0 \rangle$





Section 8.2 *(page 564)*

1. scalars **3.** BA

5. $x = -4, y = 23$ **7.** $x = -1, y = 3$

9. (a) $\begin{bmatrix} 3 & -2 \\ 1 & 7 \end{bmatrix}$ (b) $\begin{bmatrix} -1 & 0 \\ 3 & -9 \end{bmatrix}$ (c) $\begin{bmatrix} 3 & -3 \\ 6 & -3 \end{bmatrix}$
(d) $\begin{bmatrix} -1 & -1 \\ 8 & -19 \end{bmatrix}$

11. (a), (b), and (d) Not possible (c) $\begin{bmatrix} 18 & 0 & 9 \\ -3 & -12 & 0 \end{bmatrix}$

13. (a) $\begin{bmatrix} 9 & 5 \\ 1 & -2 \\ -3 & 15 \end{bmatrix}$ (b) $\begin{bmatrix} 7 & -7 \\ 3 & 8 \\ -5 & -5 \end{bmatrix}$ (c) $\begin{bmatrix} 24 & -3 \\ 6 & 9 \\ -12 & 15 \end{bmatrix}$
(d) $\begin{bmatrix} 22 & -15 \\ 8 & 19 \\ -14 & -5 \end{bmatrix}$

15. (a) $\begin{bmatrix} 5 & 5 & -2 & 4 & 4 \\ -5 & 10 & 0 & -4 & -7 \end{bmatrix}$
(b) $\begin{bmatrix} 3 & 5 & 0 & 2 & 4 \\ 7 & -6 & -4 & 2 & 7 \end{bmatrix}$
(c) $\begin{bmatrix} 12 & 15 & -3 & 9 & 12 \\ 3 & 6 & -6 & -3 & 0 \end{bmatrix}$
(d) $\begin{bmatrix} 10 & 15 & -1 & 7 & 12 \\ 15 & -10 & -10 & 3 & 14 \end{bmatrix}$

17. $\begin{bmatrix} -8 & -7 \\ 15 & -1 \end{bmatrix}$ **19.** $\begin{bmatrix} -24 & -4 & 12 \\ -12 & 32 & 12 \end{bmatrix}$

21. $\begin{bmatrix} 10 & 8 \\ -59 & 9 \end{bmatrix}$ **23.** $\begin{bmatrix} -4 & 6 & -2 \\ 4 & 0 & 10 \end{bmatrix}$

25. $\begin{bmatrix} -2 & 0 & 5 \\ -\frac{5}{2} & 0 & \frac{7}{2} \end{bmatrix}$ **27.** $\begin{bmatrix} 3 & -\frac{1}{2} & -\frac{13}{2} \\ 3 & 0 & -\frac{11}{2} \end{bmatrix}$

29. $\begin{bmatrix} 2 & -5 & 5 \\ -5 & 0 & -6 \end{bmatrix}$ **31.** $\begin{bmatrix} -2 & 51 \\ -8 & 33 \\ 0 & 27 \end{bmatrix}$ **33.** Not possible
3 × 2

35. $\begin{bmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & \frac{7}{2} \end{bmatrix}$
3 × 3

37. (a) $\begin{bmatrix} 0 & 15 \\ 6 & 12 \end{bmatrix}$ (b) $\begin{bmatrix} -2 & 2 \\ 31 & 14 \end{bmatrix}$ (c) $\begin{bmatrix} 9 & 6 \\ 12 & 12 \end{bmatrix}$

39. (a) $\begin{bmatrix} 2 & -2 \\ -3 & 0 \\ 7 & 6 \end{bmatrix}$ (b) and (c) Not possible

41. (a) $\begin{bmatrix} 19 \\ 48 \end{bmatrix}$ (b) Not possible (c) $\begin{bmatrix} 14 & -8 \\ 16 & 142 \end{bmatrix}$

43. (a) $\begin{bmatrix} 7 & 7 & 14 \\ 8 & 8 & 16 \\ -1 & -1 & -2 \end{bmatrix}$ (b) $[13]$ (c) Not possible

45. $\begin{bmatrix} 70 & -17 & 73 \\ 32 & 11 & 6 \\ 16 & -38 & 70 \end{bmatrix}$ **47.** $\begin{bmatrix} 5 & 8 \\ -4 & -16 \end{bmatrix}$ **49.** $\begin{bmatrix} -4 & 10 \\ 3 & 14 \end{bmatrix}$

51. (a) $\langle 4, 7 \rangle$ (b) $\langle -2, 3 \rangle$ (c) $\langle 8, 1 \rangle$

53. (a) $\langle 3, 6 \rangle$ (b) $\langle -7, -2 \rangle$ (c) $\langle 17, 10 \rangle$

55. $\langle 4, -2 \rangle$; Reflection in the x-axis

57. $\langle 2, 4 \rangle$; Reflection in the line $y = x$

59. $\langle 8, 2 \rangle$; Horizontal stretch

61. (a) $\begin{bmatrix} 2 & 3 \\ 1 & 4 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \end{bmatrix} = \begin{bmatrix} 5 \\ 10 \end{bmatrix}$ (b) $\begin{bmatrix} -2 \\ 3 \end{bmatrix}$

63. (a) $\begin{bmatrix} 1 & -2 & 3 \\ -1 & 3 & -1 \\ 2 & -5 & 5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} 9 \\ -6 \\ 17 \end{bmatrix}$ (b) $\begin{bmatrix} 1 \\ -1 \\ 2 \end{bmatrix}$

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65. (a) $\begin{bmatrix} 1 & -5 & 2 \\ -3 & 1 & -1 \\ 0 & -2 & 5 \end{bmatrix}\begin{bmatrix} x_1 \\ x_2 \\ x_3 \end{bmatrix} = \begin{bmatrix} -20 \\ 8 \\ -16 \end{bmatrix}$ (b) $\begin{bmatrix} -1 \\ 3 \\ -2 \end{bmatrix}$

67. $\begin{bmatrix} 110 & 99 & 77 & 33 \\ 44 & 22 & 66 & 66 \end{bmatrix}$

69. [\$1037.50 \$1400 \$1012.50]
The entries represent the profits from both crops at each of the three outlets.

71. $\begin{bmatrix} \$23.20 & \$20.50 \\ \$38.20 & \$33.80 \\ \$76.90 & \$68.50 \end{bmatrix}$
The entries represent the labor costs at each factory for each size of boat.

73. (a) $B = [2 \quad 0.25 \quad 0.5]$
(b) $BA = [1180 \quad 1407.5]$
BA represents the total calories burned by each person.
(c) 130-lb person: 398.25 calories
155-lb person: 475.05 calories

75. False. For most matrices, $AB \neq BA$.

77. $\begin{bmatrix} 1 & 0 \\ 2 & 1 \end{bmatrix} \neq \begin{bmatrix} 0 & 0 \\ 3 & 2 \end{bmatrix}$ **79.** $\begin{bmatrix} 3 & -2 \\ 4 & 3 \end{bmatrix} \neq \begin{bmatrix} 2 & -2 \\ 5 & 4 \end{bmatrix}$

81. $AC = BC = \begin{bmatrix} 2 & 3 \\ 2 & 3 \end{bmatrix}$

83. AB is a diagonal matrix whose entries are the products of the corresponding entries of A and B.

85. Answers will vary.

87. (a) $A^2 = \begin{bmatrix} -1 & 0 \\ 0 & -1 \end{bmatrix}$ and $i^2 = -1$
$A^3 = \begin{bmatrix} -i & 0 \\ 0 & -i \end{bmatrix}$ and $i^3 = -i$
$A^4 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix}$ and $i^4 = 1$
(b) $B^2 = \begin{bmatrix} 1 & 0 \\ 0 & 1 \end{bmatrix} = I$, the identity matrix

89. $1 + \log_3 5 + \log_3 x$ **91.** $\ln a - 3 \ln b$

93. $\left(\frac{4}{5}, 1\right)$ **95.** $(-2, 3, 0)$

Section 8.3 *(page 574)*

1. inverse

3. A square matrix that is singular does not have an inverse.

5–11. $AB = I$ and $BA = I$

13. $\begin{bmatrix} -3 & 2 \\ -2 & 1 \end{bmatrix}$ **15.** $\begin{bmatrix} 1 & -\frac{1}{2} \\ -2 & \frac{3}{2} \end{bmatrix}$ **17.** $\begin{bmatrix} 1 & 1 & -1 \\ -3 & 2 & -1 \\ 3 & -3 & 2 \end{bmatrix}$

19. Not possible

21. $\begin{bmatrix} -\frac{1}{8} & 0 & 0 & 0 \\ 0 & 1 & 0 & 0 \\ 0 & 0 & \frac{1}{4} & 0 \\ 0 & 0 & 0 & -\frac{1}{5} \end{bmatrix}$ **23.** $\begin{bmatrix} -175 & 37 & -13 \\ 95 & -20 & 7 \\ 14 & -3 & 1 \end{bmatrix}$

25. $\begin{bmatrix} -12 & -5 & -9 \\ -4 & -2 & -4 \\ -8 & -4 & -6 \end{bmatrix}$ **27.** $\begin{bmatrix} 0 & -1.\overline{81} & 0.\overline{90} \\ -10 & 5 & 5 \\ 10 & -2.\overline{72} & -3.\overline{63} \end{bmatrix}$

29. $\begin{bmatrix} 1 & 0 & 1 & 0 \\ 0 & 1 & 0 & 1 \\ 2 & 0 & 1 & 0 \\ 0 & 1 & 0 & 2 \end{bmatrix}$ **31.** $\begin{bmatrix} \frac{5}{13} & -\frac{3}{13} \\ \frac{1}{13} & \frac{2}{13} \end{bmatrix}$

33. Not possible **35.** $\begin{bmatrix} -4 & 2 \\ 10 & -\frac{10}{3} \end{bmatrix}$ **37.** $(5, 0)$

39. $(-8, -6)$ **41.** $(3, 8, -11)$ **43.** $(2, 1, 0, 0)$

45. $(-1, 1)$ **47.** No solution **49.** $(-4, -8)$

51. $(-1, 3, 2)$ **53.** $\left(\frac{13}{16}, \frac{11}{16}, 0\right)$

55. $I_1 = 0.5$ amp
$I_2 = 3$ amps
$I_3 = 3.5$ amps

57. $I_1 = 4$ amps
$I_2 = 1$ amp
$I_3 = 5$ amps

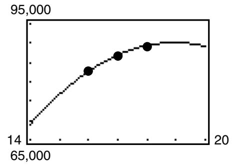
59. 100 bags of potting soil for seedlings
100 bags of potting soil for general potting
100 bags of potting soil for hardwood plants

61. (a) $\begin{cases} 256a + 16b + c = 82{,}700 \\ 289a + 17b + c = 86{,}918 \\ 324a + 18b + c = 89{,}400 \end{cases}$

(b) $\begin{bmatrix} 0.5 & -1 & 0.5 \\ -17.5 & 34 & -16.5 \\ 153 & -288 & 136 \end{bmatrix}$

(c) $y = -868t^2 + 32{,}862t - 220{,}884$

(d)



63. True. If B is the inverse of A, then $AB = I = BA$.

65–67. Answers will vary.

69. $k = -\frac{3}{2}$ **71.** 23 **73.** -152 **75.** 8

77. $\begin{bmatrix} 11 & 14 \\ 10 & -9 \end{bmatrix}$ **79.** $\begin{bmatrix} -\frac{7}{2} & 3 \\ 0 & -4 \end{bmatrix}$

Section 8.4 *(page 582)*

1. determinant **3.** -5 **5.** 4 **7.** 16 **9.** -3

11. 0 **13.** 11 **15.** 0 **17.** $\frac{11}{6}$ **19.** -1924

21. 0.08

23. (a) $M_{11} = -6, M_{12} = 3, M_{21} = 5, M_{22} = 4$
(b) $C_{11} = -6, C_{12} = -3, C_{21} = -5, C_{22} = 4$

25. (a) $M_{11} = 3, M_{12} = -4, M_{13} = 1, M_{21} = 2, M_{22} = 2, M_{23} = -4, M_{31} = -4, M_{32} = 10, M_{33} = 8$
(b) $C_{11} = 3, C_{12} = 4, C_{13} = 1, C_{21} = -2, C_{22} = 2, C_{23} = 4, C_{31} = -4, C_{32} = -10, C_{33} = 8$

27. (a) $M_{11} = 10, M_{12} = -43, M_{13} = 2, M_{21} = -30, M_{22} = 17, M_{23} = -6, M_{31} = 54, M_{32} = -53, M_{33} = -34$
(b) $C_{11} = 10, C_{12} = 43, C_{13} = 2, C_{21} = 30, C_{22} = 17, C_{23} = 6, C_{31} = 54, C_{32} = 53, C_{33} = -34$

29. (a) and (b) -36 **31.** (a) and (b) 96

33. (a) and (b) -75 **35.** (a) and (b) 0

37. (a) and (b) 225 **39.** -9 **41.** 0 **43.** 0

45. -58 **47.** 72 **49.** 0 **51.** 412 **53.** -126

55. -336 **57.** (a) -3 (b) -2 (c) $\begin{bmatrix} -2 & 0 \\ 0 & -3 \end{bmatrix}$ (d) 6

59. (a) -8 (b) 0 (c) $\begin{bmatrix} -4 & 4 \\ 1 & -1 \end{bmatrix}$ (d) 0

61. (a) 2 (b) -6 (c) $\begin{bmatrix} 1 & 4 & 3 \\ -1 & 0 & 3 \\ 0 & 2 & 0 \end{bmatrix}$ (d) -12

63. $A = \begin{bmatrix} 3 & 3 \\ 1 & 2 \end{bmatrix}$ **65.** $A = \begin{bmatrix} 4 & 2 & -1 \\ 2 & 1 & 0 \\ 1 & 1 & 3 \end{bmatrix}$

67. $A = \begin{bmatrix} 2 & 3 \\ 8 & 12 \end{bmatrix}$

69–73. Answers will vary. **75.** ± 2 **77.** $-2, 1$

79. $-1, -4$ **81.** $8uv - 1$ **83.** e^{5x} **85.** $1 - \ln x$

87. True. If an entire row is zero, then each cofactor in the expansion is multiplied by zero.

89. Answers will vary.

91. (a) Columns 2 and 3 of A were interchanged.
$|A| = -115 = -|B|$
(b) Add -5 times Row 1 to Row 2.
$|A| = 17 = |B|$
(c) Multiply Row 1 by 5.

93. (a) 28 (b) -10 (c) -12
The determinant of a diagonal matrix is the product of the entries on the main diagonal.

95. 3 **97.** 29 **99.** 72 **101.** $(2, -1)$

103. $(2, -3, 1)$ **105.** $\begin{bmatrix} -2 \\ 0 \end{bmatrix}$

Section 8.5 *(page 595)*

1. Cramer's Rule **3.** -5 **5.** $(1, -1)$

7. Not possible **9.** $(-1, 3, 2)$ **11.** $(-2, 1, -1)$

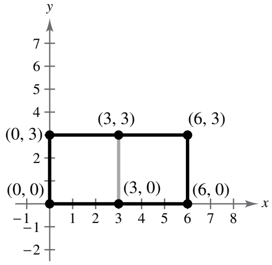
13. 7 **15.** 14 **17.** $y = \frac{16}{5}$ or $y = 0$ **19.** 250 mi^2

21. Collinear **23.** Not collinear **25.** Collinear

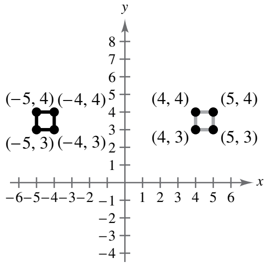
27. $y = -3$ **29.** $3x - 5y = 0$ **31.** $x + 3y - 5 = 0$

33. $2x + 3y - 8 = 0$

35. $(0, 0)$, $(0, 3)$, $(6, 0)$, $(6, 3)$



37. $(-4, 3)$, $(-5, 3)$, $(-4, 4)$, $(-5, 4)$



39. 2 square units **41.** 10 square units

43. (a) Uncoded: $[3 \quad 15]$, $[13 \quad 5]$, $[0 \quad 8]$, $[15 \quad 13]$, $[5 \quad 0]$, $[19 \quad 15]$, $[15 \quad 14]$
(b) Encoded: 48 81 28 51 24 40 54 95 5 10 64 113 57 100

45. (a) Uncoded: $[20 \quad 5 \quad 24]$, $[20 \quad 0 \quad 13]$, $[5 \quad 0 \quad 20]$, $[15 \quad 13 \quad 15]$, $[18 \quad 18 \quad 15]$, $[23 \quad 0 \quad 0]$
(b) Encoded: -119 28 67 -58 6 39 -115 35 60 -62 15 32 -54 12 27 23 -23 0

47. 26 21 -18 35 52 31 13 30 38 79 173 206 -1 -35 -82 16 -4 -55 12 24 24

49. -5 -41 -87 91 207 257 11 -5 -41 40 80 84 76 177 227

51. HAPPY NEW YEAR **53.** CLASS IS CANCELED

55. MEET ME TONIGHT RON

57. $I_1 = -0.5$ amp
$I_2 = 1$ amp
$I_3 = 0.5$ amp

59. True. The determinant is zero when the points are collinear.

61. The system has either no solution or infinitely many solutions.

63. 12 **65.** $2, 4, 2, 4$ **67.** $2, -5, 10, -17$

Review Exercises *(page 600)*

1. 1×2 **3.** 2×5

5. $\left[\begin{array}{cc|c} 3 & -10 & 15 \\ 5 & 4 & 22 \end{array}\right]$ **7.** $\begin{cases} x + 2z = -8 \\ 2x - 2y + 3z = 12 \\ 4x + 7y + z = 3 \end{cases}$

9. $\begin{bmatrix} 1 & 2 & 3 \\ 0 & 1 & 1 \\ 0 & 0 & 1 \end{bmatrix}$

11. $\begin{cases} x - 3y = 9 \\ y = -1 \end{cases}$
$(6, -1)$

13. $\begin{cases} x + 3y + 4z = 1 \\ y + 2z = 3 \\ z = 4 \end{cases}$
$(0, -5, 4)$

15. $(10, -12)$ **17.** No solution **19.** $\left(-2a + \frac{3}{2}, 2a + 1, a\right)$

21. $(5, 2, -6)$ **23.** $(1, -2, 2, -4)$ **25.** $(1, 2, 2)$

27. $(2, -3, 3)$ **29.** $(2, 6, -10, -3)$ **31.** $x = 12, y = 11$

33. $x = 1, y = 11$

35. (a) $\begin{bmatrix} -1 & 8 \\ 15 & 13 \end{bmatrix}$ (b) $\begin{bmatrix} 5 & -12 \\ -9 & -3 \end{bmatrix}$
(c) $\begin{bmatrix} 8 & -8 \\ 12 & 20 \end{bmatrix}$ (d) $\begin{bmatrix} -2 & 16 \\ 30 & 26 \end{bmatrix}$

37. (a) $\begin{bmatrix} 5 & 7 \\ -3 & 14 \\ 31 & 42 \end{bmatrix}$ (b) $\begin{bmatrix} 5 & 1 \\ -11 & -10 \\ -9 & -38 \end{bmatrix}$
(c) $\begin{bmatrix} 20 & 16 \\ -28 & 8 \\ 44 & 8 \end{bmatrix}$ (d) $\begin{bmatrix} 10 & 14 \\ -6 & 28 \\ 62 & 84 \end{bmatrix}$

39. $\begin{bmatrix} 22 & -17 \\ 14 & 11 \end{bmatrix}$ **41.** $\begin{bmatrix} -16 & -6 \\ -12 & 4 \\ -14 & -8 \end{bmatrix}$ **43.** $\begin{bmatrix} -11 & -6 \\ 8 & -13 \\ -18 & -8 \end{bmatrix}$

45. $\begin{bmatrix} 3 & \frac{2}{3} \\ -\frac{4}{3} & \frac{11}{3} \\ \frac{10}{3} & 0 \end{bmatrix}$ **47.** $\begin{bmatrix} -30 & 4 \\ 51 & 70 \end{bmatrix}$; 2×2

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49. $\begin{bmatrix}100 & 220\\ 12 & -4\\ 84 & 212\end{bmatrix}$; 3 × 2

51. (a) $\begin{bmatrix}-1 & -1\\ 18 & -4\end{bmatrix}$ (b) $\begin{bmatrix}1 & 14\\ -2 & -6\end{bmatrix}$ (c) $\begin{bmatrix}13 & 6\\ 8 & 13\end{bmatrix}$

53. $\begin{bmatrix}14 & -22 & 22\\ 19 & -41 & 80\\ 42 & -66 & 66\end{bmatrix}$ **55.** $\begin{bmatrix}-2 & 19 & 21\\ -2 & 1 & -3\end{bmatrix}$

57. $\langle 2, -5\rangle$; Reflection in the x-axis

59. $\langle 1, 5\rangle$; Horizontal shrink **61.** $\begin{bmatrix}76 & 114 & 133\\ 38 & 95 & 76\end{bmatrix}$

63–65. $AB = I$ and $BA = I$

67. $\begin{bmatrix}4 & -5\\ 5 & -6\end{bmatrix}$

69. $\begin{bmatrix}\frac{1}{2} & -1 & -\frac{1}{2}\\ \frac{1}{2} & -\frac{2}{3} & -\frac{5}{6}\\ 0 & \frac{2}{3} & \frac{1}{3}\end{bmatrix}$ **71.** $\begin{bmatrix}13 & 6 & -4\\ -12 & -5 & 3\\ 5 & 2 & -1\end{bmatrix}$

73. $\begin{bmatrix}1 & -1\\ 4 & -\frac{7}{2}\end{bmatrix}$ **75.** Not possible **77.** $(36, 11)$

79. $(-6, -1)$ **81.** No solution **83.** $(-8, 18)$

85. $(2, -1, -2)$ **87.** $(-65.8, 33.6)$ **89.** 26 **91.** 116

93. (a) $M_{11} = 4, M_{12} = 7, M_{21} = -1, M_{22} = 2$

(b) $C_{11} = 4, C_{12} = -7, C_{21} = 1, C_{22} = 1$

95. (a) $M_{11} = 30, M_{12} = -12, M_{13} = -21, M_{21} = 20,$
$M_{22} = 19, M_{23} = 22, M_{31} = 5, M_{32} = -2, M_{33} = 19$

(b) $C_{11} = 30, C_{12} = 12, C_{13} = -21, C_{21} = -20,$
$C_{22} = 19, C_{23} = -22, C_{31} = 5, C_{32} = 2, C_{33} = 19$

97. -6 **99.** 15 **101.** 130 **103.** $(4, 7)$

105. $(-1, 4, 5)$ **107.** 16 **109.** Collinear

111. $x - 2y + 4 = 0$ **113.** $2x + 6y - 13 = 0$

115. 8 square units **117.** SEE YOU FRIDAY

119. False. The matrix must be square.

121. If A is a square matrix, then the cofactor C_{ij} of the entry a_{ij} is $(-1)^{i+j}M_{ij}$, where M_{ij} is the determinant obtained by deleting the ith row and jth column of A. The determinant of A is the sum of the entries of any row or column of A multiplied by their respective cofactors.

Chapter Test *(page 604)*

1. $\begin{bmatrix}1 & 0 & 0\\ 0 & 1 & 0\\ 0 & 0 & 1\end{bmatrix}$ **2.** $\begin{bmatrix}1 & 0 & -1 & 2\\ 0 & 1 & 0 & -1\\ 0 & 0 & 0 & 0\\ 0 & 0 & 0 & 0\end{bmatrix}$

3. $\begin{bmatrix}4 & 3 & -2 & \vdots & 14\\ -1 & -1 & 2 & \vdots & -5\\ 3 & 1 & -4 & \vdots & 8\end{bmatrix}$, $\left(1, 3, -\frac{1}{2}\right)$

4. (a) $\begin{bmatrix}1 & 5\\ 0 & -4\end{bmatrix}$ (b) $\begin{bmatrix}6 & -3 & 12\\ 0 & 18 & -9\end{bmatrix}$

(c) $\begin{bmatrix}8 & 15\\ -5 & -13\end{bmatrix}$ (d) $\begin{bmatrix}10 & -5 & 20\\ -10 & -1 & -17\end{bmatrix}$

(e) Not possible

5. $\langle -3, -2\rangle$; Reflection in the line $y = -x$

6. $\begin{bmatrix}\frac{2}{7} & \frac{3}{7}\\ \frac{5}{7} & \frac{4}{7}\end{bmatrix}$ **7.** $\begin{bmatrix}-\frac{5}{2} & 4 & -3\\ 5 & -7 & 6\\ 4 & -6 & 5\end{bmatrix}$ **8.** $(12, 18)$

9. -112 **10.** 0 **11.** 43 **12.** $(-3, 5)$

13. $(-2, 4, 6)$ **14.** 7

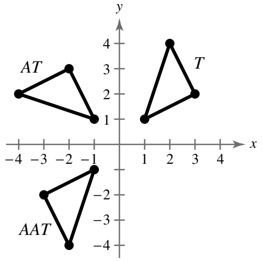
15. Uncoded: $[11\ \ 14\ \ 15], [3\ \ 11\ \ 0], [15\ \ 14\ \ 0], [23\ \ 15\ \ 15],$
$[4\ \ 0\ \ 0]$

Encoded: $115\ \ -41\ \ -59\ \ 14\ \ -3\ \ -11\ \ 29\ \ -15$
$-14\ \ 128\ \ -53\ \ -60\ \ 4\ \ -4\ \ 0$

16. 75 L of 60% solution, 25 L of 20% solution

Problem Solving *(page 607)*

1. (a) $AT = \begin{bmatrix}-1 & -4 & -2\\ 1 & 2 & 3\end{bmatrix}, AAT = \begin{bmatrix}-1 & -2 & -3\\ -1 & -4 & -2\end{bmatrix}$



A represents a counterclockwise rotation.

(b) AAT is rotated clockwise 90° to obtain AT. AT is then rotated clockwise 90° to obtain T.

3. (a) Yes (b) No (c) No (d) No (e) No (f) No

5. (a)
$$A^2 - 2A + 5I = \begin{bmatrix}1 & 2\\ -2 & 1\end{bmatrix}^2 - 2\begin{bmatrix}1 & 2\\ -2 & 1\end{bmatrix} + 5\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix}$$
$$= \begin{bmatrix}-3 & 4\\ -4 & -3\end{bmatrix} - \begin{bmatrix}2 & 4\\ -4 & 2\end{bmatrix} + \begin{bmatrix}5 & 0\\ 0 & 5\end{bmatrix}$$
$$= \begin{bmatrix}0 & 0\\ 0 & 0\end{bmatrix}$$

(b)
$$A^{-1} = \frac{1}{5}(2I - A)$$
$$\begin{bmatrix}1 & 2\\ -2 & 1\end{bmatrix}^{-1} = \frac{1}{5}\left(2\begin{bmatrix}1 & 0\\ 0 & 1\end{bmatrix} - \begin{bmatrix}1 & 2\\ -2 & 1\end{bmatrix}\right)$$
$$\begin{bmatrix}\frac{1}{5} & -\frac{2}{5}\\ \frac{2}{5} & \frac{1}{5}\end{bmatrix} = \frac{1}{5}\left(\begin{bmatrix}2 & 0\\ 0 & 2\end{bmatrix} - \begin{bmatrix}1 & 2\\ -2 & 1\end{bmatrix}\right)$$
$$\begin{bmatrix}\frac{1}{5} & -\frac{2}{5}\\ \frac{2}{5} & \frac{1}{5}\end{bmatrix} = \frac{1}{5}\begin{bmatrix}1 & -2\\ 2 & 1\end{bmatrix}$$
$$\begin{bmatrix}\frac{1}{5} & -\frac{2}{5}\\ \frac{2}{5} & \frac{1}{5}\end{bmatrix} = \begin{bmatrix}\frac{1}{5} & -\frac{2}{5}\\ \frac{2}{5} & \frac{1}{5}\end{bmatrix}$$

(c) Answers will vary.

7. $A^T = \begin{bmatrix}-1 & 2\\ 1 & 0\\ -2 & 1\end{bmatrix}$, $B^T = \begin{bmatrix}-3 & 1 & 1\\ 0 & 2 & -1\end{bmatrix}$

$(AB)^T = \begin{bmatrix}2 & -5\\ 4 & -1\end{bmatrix} = B^TA^T$

9. $x = 6$ **11.** Answers will vary.

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13. $\begin{vmatrix} x & 0 & 0 & d \\ -1 & x & 0 & c \\ 0 & -1 & x & b \\ 0 & 0 & -1 & a \end{vmatrix}$

15. Sulfur: 32 atomic mass units
Nitrogen: 14 atomic mass units
Fluorine: 19 atomic mass units

17. REMEMBER SEPTEMBER THE ELEVENTH

19. $A^{-1} = \begin{bmatrix} 0.0625 & -0.4375 & 0.625 \\ 0.1875 & 0.6875 & -1.125 \\ -0.125 & -0.125 & 0.75 \end{bmatrix}$

$|A^{-1}| = \dfrac{1}{16}, |A| = 16$

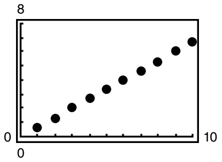
$|A^{-1}| = \dfrac{1}{|A|}$

Chapter 9

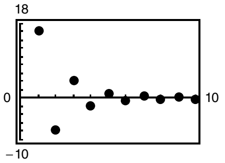
Section 9.1 *(page 617)*

1. recursively **3.** series **5.** 6! **7.** $-3, 1, 5, 9, 13$
9. 5, 3, 5, 3, 5 **11.** $\frac{2}{3}, \frac{2}{3}, \frac{2}{3}, \frac{2}{3}, \frac{2}{3}$ **13.** $-2, 4, -8, 16, -32$
15. $\frac{1}{3}, \frac{8}{3}, 9, \frac{64}{3}, \frac{125}{3}$ **17.** $\frac{1}{3}, \frac{1}{2}, \frac{3}{5}, \frac{2}{3}, \frac{5}{7}$ **19.** 0, 0, 6, 24, 60
21. $-\frac{1}{2}, \frac{2}{3}, -\frac{3}{4}, \frac{4}{5}, -\frac{5}{6}$ **23.** -73 **25.** $\frac{44}{239}$

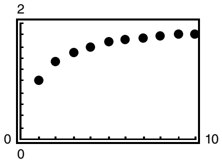
27.



29.



31.



33. $a_n = 4n - 1$ **35.** $a_n = n^3 + 2$ **37.** $a_n = (-1)^{n+1}$

39. $a_n = \dfrac{(-1)^n(n + 1)}{n + 2}$ **41.** $a_n = \dfrac{n + 1}{2n - 1}$ **43.** $a_n = \dfrac{1}{n!}$

45. $a_n = \dfrac{3^{n-1}}{(n - 1)!}$

47. 28, 24, 20, 16, 12 **49.** 81, 27, 9, 3, 1 **51.** $1, 2, 2, 3, \frac{7}{2}$

53. 1, 1, 2, 3, 5, 8, 13, 21, 34, 55, 89, 144
$1, 2, \frac{3}{2}, \frac{5}{3}, \frac{8}{5}, \frac{13}{8}, \frac{21}{13}, \frac{34}{21}, \frac{55}{34}, \frac{89}{55}$

55. $5, 5, \frac{5}{2}, \frac{5}{6}, \frac{5}{24}$ **57.** $6, -24, 60, -120, 210$

59. $\dfrac{1}{30}$ **61.** $n + 1$ **63.** 25 **65.** $\frac{124}{429}$ **67.** 88

69. $\frac{13}{4}$ **71.** $\frac{3}{8}$ **73.** 1.33 **75.** $\displaystyle\sum_{i=1}^{9} \frac{1}{3i}$

77. $\displaystyle\sum_{i=1}^{8} \left[2\left(\frac{i}{8}\right) + 3\right]$ **79.** $\displaystyle\sum_{i=1}^{6} (-1)^{i+1}3^i$ **81.** $\displaystyle\sum_{i=1}^{7} \frac{i^2}{(i + 1)!}$

83. $\displaystyle\sum_{i=1}^{5} \frac{2^i - 1}{2^{i+1}}$ **85.** (a) $\dfrac{7}{8}$ (b) $\dfrac{15}{16}$ (c) $\dfrac{31}{32}$

87. (a) $-\frac{3}{2}$ (b) $-\frac{5}{4}$ (c) $-\frac{11}{8}$ **89.** $\frac{2}{3}$ **91.** $\frac{7}{9}$

93. (a) $A_1 = \$10{,}087.50$, $A_2 \approx \$10{,}175.77$, $A_3 \approx \$10{,}264.80$, $A_4 \approx \$10{,}354.62$, $A_5 \approx \$10{,}445.22$, $A_6 \approx \$10{,}536.62$, $A_7 \approx \$10{,}628.81$, $A_8 \approx \$10{,}721.82$
(b) \$14,169.09
(c) No. $A_{80} \approx \$20{,}076.31 \neq 2A_{40} \approx \$28{,}338.18$

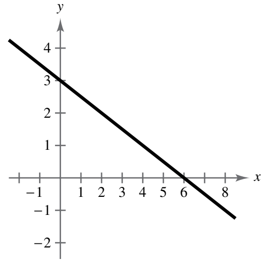
95. True by the Properties of Sums.

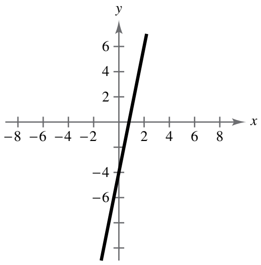
97. \$500.95 **99.** Proof

101. $\displaystyle\sum_{k=1}^{4} 3 = 3(4) = 12$

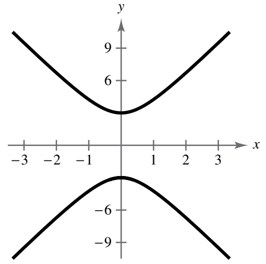
103. $b_1 = \frac{1}{3}, b_2 = -\frac{1}{5}, b_3 = \frac{1}{7}, b_4 = -\frac{1}{9}; b_n = -a_n$

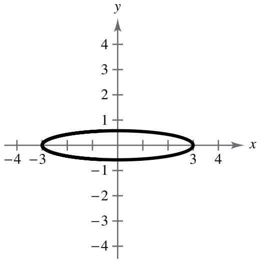
105. $y = -\frac{1}{2}x + 3$ **107.** $y = 5x - 4$





109. Vertices: $(0, \pm 3)$ **111.** Vertices: $(\pm 3, 0)$





113. $2\mathbf{i} - 4\mathbf{j}$ **115.** $-9\mathbf{i} + 5\mathbf{j}$

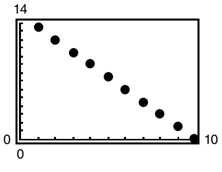
Section 9.2 *(page 626)*

1. $a_1 + (n - 1)d$

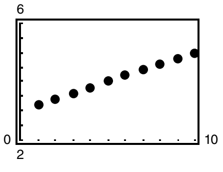
3. A sequence is arithmetic when the differences between consecutive terms are the same.

5. Not arithmetic **7.** Arithmetic, $d = -2$
9. Arithmetic, $d = \frac{1}{4}$ **11.** Not arithmetic
13. 8, 11, 14, 17, 20
Arithmetic, $d = 3$
15. $7, 3, -1, -5, -9$
Arithmetic, $d = -4$
17. $-1, 1, -1, 1, -1$
Not arithmetic
19. 2, 8, 24, 64, 160
Not arithmetic
21. $a_n = 3n - 2$ **23.** $a_n = -8n + 108$
25. $a_n = -\frac{5}{2}n + \frac{13}{2}$ **27.** $a_n = \frac{10}{3}n + \frac{5}{3}$
29. $a_n = 3n + 85$ **31.** 5, 11, 17, 23, 29
33. $2, -4, -10, -16, -22$ **35.** $-2, 2, 6, 10, 14$
37. 15, 19, 23, 27, 31 **39.** 15, 13, 11, 9, 7
41. -49 **43.** $\frac{31}{8}$ **45.** 110 **47.** -25 **49.** 10,000
51. 15,100 **53.** -7020 **55.** 1275 **57.** 129,250
59. $-28{,}300$ **61.** b **62.** d **63.** c **64.** a

65.



67.



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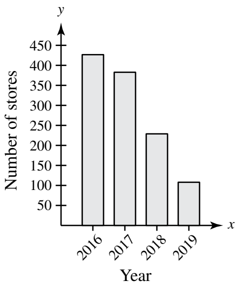
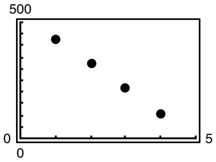
69. (a) \$40,000 (b) \$217,500 **71.** 2430 seats

73. (a)



(b) $a_n = 533.33 - 106.33n$

(c)

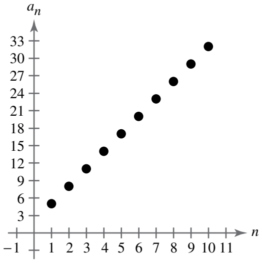


(d) $\sum_{n=1}^{4} (533.33 - 106.33n)$; About 1070 stores

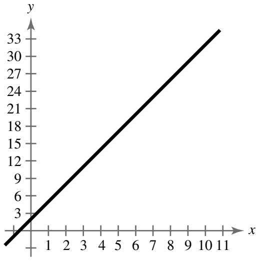
75. 784 ft

77. True. Given a_1 and a_2, $d = a_2 - a_1$ and $a_n = a_1 + (n - 1)d$.

79. (a)



(b)



(c) The graph of $y = 3x + 2$ contains all points on the line. The graph of $a_n = 2 + 3n$ contains only points at the positive integers.

(d) The slope of the line and the common difference of the arithmetic sequence are equal.

81. $x, 3x, 5x, 7x, 9x, 11x, 13x, 15x, 17x, 19x$

83. When $n = 50$, $a_n = 2(50) - 1 = 99$.

85. -0.205 **87.** 1.292 **89.** 25 **91.** 9.322

93. $14x + \dfrac{14}{x + 1}, x \neq 1$ **95.** $\dfrac{3}{4(x + 2)} + \dfrac{1}{4(x - 2)}$

Section 9.3 *(page 635)*

1. ratio **3.** Multiply the nth term by the common ratio.

5. Geometric, $r = 2$ **7.** Geometric, $r = 3$

9. Not geometric **11.** Geometric, $r = -\sqrt{7}$

13. 4, 12, 36, 108, 324 **15.** $1, \frac{1}{2}, \frac{1}{4}, \frac{1}{8}, \frac{1}{16}$

17. $1, e, e^2, e^3, e^4$ **19.** $3, 3\sqrt{5}, 15, 15\sqrt{5}, 75$

21. $2, 6x, 18x^2, 54x^3, 162x^4$ **23.** $a_n = 4\left(\frac{1}{2}\right)^{n-1}; \frac{1}{128}$

25. $a_n = 6\left(-\dfrac{1}{3}\right)^{n-1}; -\dfrac{2}{59{,}049}$ **27.** $a_n = 100e^{x(n-1)}; 100e^{8x}$

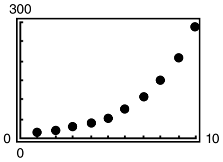
29. $a_n = \left(\sqrt{2}\right)^{n-1}; 32\sqrt{2}$ **31.** $a_n = 64\left(\frac{1}{2}\right)^{n-1}$

33. $a_n = 9(2)^{n-1}$ **35.** $a_n = 6\left(-\frac{3}{2}\right)^{n-1}$ **37.** 13,122

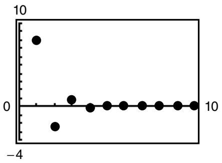
39. $\frac{1}{768}$ **41.** 9 **43.** -2 **45.** a

46. c **47.** b **48.** d

49.



51.



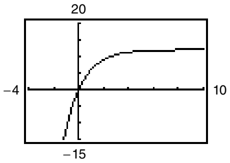
53. 5461 **55.** $-14{,}706$ **57.** 29,921.311 **59.** 1360.383

61. 1.6 **63.** $\sum_{n=1}^{7} 10(3)^{n-1}$ **65.** $\sum_{n=1}^{6} 0.1(4)^{n-1}$ **67.** 2

69. $\dfrac{6}{5}$ **71.** 5 **73.** 32 **75.** Undefined **77.** $\frac{4}{11}$

79. $\frac{7}{22}$

81.



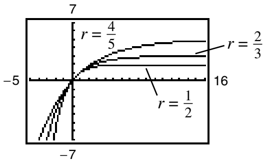
Horizontal asymptote: $y = 12$

Corresponds to the sum of the series

83. \$29,412.25 **85.** Answers will vary. **87.** $273\frac{8}{9}$ in.^{2}

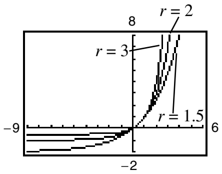
89. False. A sequence is geometric when the ratios of consecutive terms are the same.

91. (a)



As $x \to \infty, y \to \dfrac{1}{1 - r}$.

(b)



As $x \to \infty, y \to \infty$.

93. The common ratio is 2.

95. Prime; 97 has only two positive factors, itself and 1.

97. Prime; 65,537 has only two positive factors, itself and 1.

99–101. Answers will vary.

Section 9.4 *(page 646)*

1. mathematical induction

3. To find the first differences of a sequence, subtract consecutive terms.

5. $\dfrac{5}{(k + 1)(k + 2)}$ **7.** $(k + 1)^2(k + 4)^2$

9–25. Proofs **27.** $S_n = n(2n - 1)$; Proof

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29. $S_n = \dfrac{n}{2(n+1)}$; Proof **31.** 120 **33.** 979

35. 70 **37.** Linear; $a_n = 9n - 4$

39. Quadratic; $a_n = 2n^2 + 2$

41. 0, 3, 6, 9, 12, 15
First differences: 3, 3, 3, 3, 3
Second differences: 0, 0, 0, 0
Linear

43. 4, 10, 19, 31, 46, 64
First differences: 6, 9, 12, 15, 18
Second differences: 3, 3, 3, 3
Quadratic

45. $a_n = n^2 - n + 3$

47. 0, -0.02, -0.04, -0.06, -0.08; No; The first differences are not equal.

49. False. A sequence with n terms has $n - 2$ second differences.

51. The formula $\dfrac{n(n+1)(2n+1)}{6}$ should be used.

So, $1^2 + 2^2 + 3^2 + \ldots + 9^2 = \dfrac{9(9+1)(18+1)}{6} = 285.$

53. At some point, the pattern may fail. **55.** $x^2 + 2xy + y^2$

57. $y^4 - 8y^3 + 24y^2 - 32y + 16$ **59.** $x^6 + 12x^4 + 48x^2 + 64$

61. 1 **63.** 120 **65.** 1 **67.** -4

Section 9.5 *(page 653)*

1. expanding **3.** Binomial Theorem; Pascal's Triangle

5. 10 **7.** 1 **9.** 210 **11.** 4950 **13.** 20

15. 5 **17.** $x^6 + 6x^5 + 15x^4 + 20x^3 + 15x^2 + 6x + 1$

19. $y^3 - 9y^2 + 27y - 27$ **21.** $r^3 + 9r^2s + 27rs^2 + 27s^3$

23. $243a^5 - 1620a^4b + 4320a^3b^2 - 5760a^2b^3$
$+ 3840ab^4 - 1024b^5$

25. $a^4 + 24a^3 + 216a^2 + 864a + 1296$

27. $y^6 - 6y^5 + 15y^4 - 20y^3 + 15y^2 - 6y + 1$

29. $81 - 216z + 216z^2 - 96z^3 + 16z^4$

31. $x^5 + 10x^4y + 40x^3y^2 + 80x^2y^3 + 80xy^4 + 32y^5$

33. $x^8 + 4x^6y^2 + 6x^4y^4 + 4x^2y^6 + y^8$

35. $\dfrac{1}{x^5} + \dfrac{5y}{x^4} + \dfrac{10y^2}{x^3} + \dfrac{10y^3}{x^2} + \dfrac{5y^4}{x} + y^5$

37. $2x^4 - 24x^3 + 113x^2 - 246x + 207$

39. $120x^7y^3$ **41.** $360x^3y^2$ **43.** $1{,}259{,}712x^2y^7$

45. $-4{,}330{,}260{,}000y^9x^3$ **47.** 160 **49.** 720

51. $-6{,}300{,}000$ **53.** 210

55. $x^{3/2} + 15x + 75x^{1/2} + 125$

57. $x^2 - 3x^{4/3}y^{1/3} + 3x^{2/3}y^{2/3} - y$

59. $81t^2 + 108t^{7/4} + 54t^{3/2} + 12t^{5/4} + t$

61. $3x^2 + 3xh + h^2,\ h \neq 0$

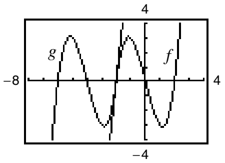
63. $6x^5 + 15x^4h + 20x^3h^2 + 15x^2h^3 + 6xh^4 + h^5,\ h \neq 0$

65. $\dfrac{1}{\sqrt{x+h} + \sqrt{x}},\ h \neq 0$ **67.** -4 **69.** $512i$

71. 1 **73.** 1.172 **75.** 510,568.785

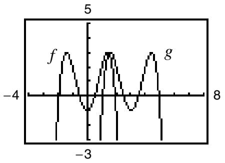
77. Fibonacci sequence

79.



The graph of g is shifted four units to the left of the graph of f.
$g(x) = x^3 + 12x^2 + 44x + 48$

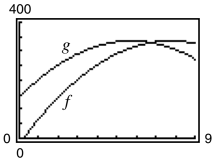
81.



The graph of g is shifted three units to the right of the graph of f.
$g(x) = -x^4 + 12x^3 - 50x^2 + 84x - 46$

83. (a) $g(t) = -5.893t^2 + 67.78t + 141.1,\ 0 \le t \le 7$

(b)



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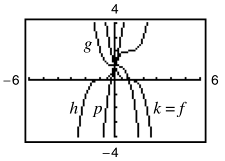
85. True. The coefficients from the Binomial Theorem can be used to find the numbers in Pascal's Triangle.

87. False. The coefficient of the x^2-term is ${}_9C_2(4)^7 = -589{,}824$. The coefficient of the x-term is ${}_9C_1(4)^8 = 589{,}824$.

89. The first and last numbers in each row are 1's. Also, each number between the 1's is the sum of the two numbers immediately above the number.

91.



k, f; $k(x)$ is the expansion of $f(x)$.

93. About 0.273 **95–97.** Proofs **99.** $\frac{1}{3}$ **101.** -9

103. 36 **105.** $\frac{1}{7}$ **107.** $(n+9)(n+8)$

109. $\sin 330° = -\dfrac{1}{2}$
$\cos 330° = \dfrac{\sqrt{3}}{2}$
$\tan 330° = -\dfrac{\sqrt{3}}{3}$

111. $\sin\left(-\dfrac{3\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$
$\cos\left(-\dfrac{3\pi}{4}\right) = -\dfrac{\sqrt{2}}{2}$
$\tan\left(-\dfrac{3\pi}{4}\right) = 1$

113. $\sin \dfrac{11\pi}{3} = -\dfrac{\sqrt{3}}{2}$
$\cos \dfrac{11\pi}{3} = \dfrac{1}{2}$
$\tan \dfrac{11\pi}{3} = -\sqrt{3}$

Section 9.6 *(page 663)*

1. distinguishable permutations

3. A given set of n elements forms exactly one combination, whereas different arrangements of the elements may form numerous permutations.

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5. 6 **7.** 5 **9.** 3 **11.** 8 **13.** 30
15. 30 **17.** 64 **19.** 175,760,000
21. (a) 648 (b) 180 (c) 600 **23.** (a) 40,320 (b) 384
25. 120 **27.** 20 **29.** 132 **31.** 2730
33. 5,527,200 **35.** 504 **37.** 1,816,214,400
39. 420 **41.** 2520
43. ABCD, ABDC, ACBD, ACDB, ADBC, ADCB, BACD, BADC, CABD, CADB, DABC, DACB, BCAD, BDAC, CBAD, CDAB, DBAC, DCAB, BCDA, BDCA, CBDA, CDBA, DBCA, DCBA
45. 15 **47.** 1 **49.** 120 **51.** 38,760
53. AB, AC, AD, AE, AF, BC, BD, BE, BF, CD, CE, CF, DE, DF, EF
55. 5,586,853,480 **57.** (a) 7315 (b) 693 (c) 12,628
59. (a) 3744 (b) 24 **61.** 292,600 **63.** 5 **65.** 20
67. $n = 2$ **69.** $n = 3$ **71.** $n = 5$ or $n = 6$
73. $n = 10$ **75.** 36
77. False. It is an example of a combination.
79. ${}_{10}P_6 > {}_{10}C_6$. Changing the order of any of the six elements selected results in a different permutation but the same combination.
81–83. Proofs **85.** $\dfrac{1}{74{,}613}$ **87.** $\dfrac{1}{3{,}338{,}335}$
89. $720x^3y^2$ **91.** $28{,}000{,}000x^2y^6$
93. $-498{,}610{,}169{,}343x^8y^5$ **95.** $y = -\frac{1}{4}x^2 + \frac{7}{2}x$

Section 9.7 *(page 674)*

1. experiment; outcomes **3.** event
5. $n(E), n(S)$ **7.** 1
9. $\{(H, 1), (H, 2), (H, 3), (H, 4), (H, 5), (H, 6), (T, 1), (T, 2), (T, 3), (T, 4), (T, 5), (T, 6)\}$
11. {ABC, ACB, BAC, BCA, CAB, CBA}
13. {AB, AC, AD, AE, BC, BD, BE, CD, CE, DE}
15. $\frac{3}{8}$ **17.** $\frac{1}{2}$ **19.** $\frac{7}{8}$ **21.** $\frac{3}{13}$ **23.** $\frac{3}{26}$ **25.** $\frac{5}{36}$
27. $\frac{11}{12}$ **29.** $\frac{1}{3}$ **31.** $\frac{1}{5}$ **33.** $\frac{2}{5}$
35. (a) 744,000 (b) $\frac{171}{1000}$ (c) $\frac{267}{500}$ (d) $\frac{171}{1000}$
37. (a) $\frac{13}{16}$ (b) $\frac{3}{16}$ (c) $\frac{1}{32}$ **39.** 19%
41. (a) $\frac{21}{1292}$ (b) $\frac{225}{646}$ (c) $\frac{49}{323}$ **43.** (a) $\frac{1}{120}$ (b) $\frac{1}{24}$
45. (a) $\frac{5}{13}$ (b) $\frac{1}{2}$ (c) $\frac{4}{13}$ **47.** (a) $\frac{14}{55}$ (b) $\frac{12}{55}$ (c) $\frac{54}{55}$
49. (a) $\frac{1}{4}$ (b) $\frac{1}{2}$ (c) $\frac{841}{1600}$ (d) $\frac{1}{40}$
51. 0.27 **53.** $\frac{4}{5}$ **55.** 0.71 **57.** $\frac{11}{25}$
59. (a) 0.9702 (b) 0.0002 (c) 0.9998
61. (a) $\frac{1}{38}$ (b) $\frac{9}{19}$ (c) $\frac{10}{19}$ (d) $\frac{1}{1444}$ (e) $\frac{729}{6859}$
63. True. Two events are independent when the occurrence of one has no effect on the occurrence of the other.
65. The three numbers from 1 to 15 greater than 12 are 13, 14, and 15. So, the probability that both numbers are greater than 12 is $\left(\frac{3}{15}\right)\left(\frac{3}{15}\right) = \frac{9}{225} = \frac{1}{25}$.
67. No; $P(A) + P(B) = 0.76 + 0.58 = 1.34 > 1$.
69. Over an extended period of time with similar weather conditions it will rain 40% of the time.
71. $2 \cos \theta = \sqrt{2}$; $\sin \theta = \pm\dfrac{\sqrt{2}}{2}$; $\cos \theta = \dfrac{\sqrt{2}}{2}$
73. $\infty, 0$ **75.** $-1 + 6i$

Review Exercises *(page 680)*

1. $15, 9, 7, 6, \frac{27}{5}$ **3.** 120, 60, 20, 5, 1 **5.** $a_n = 2(-1)^n$
7. $a_n = \dfrac{3^n}{n}$ **9.** $\dfrac{1}{20}$ **11.** $\dfrac{1}{n(n+1)}$ **13.** $\dfrac{205}{24}$
15. $\displaystyle\sum_{k=1}^{20} \frac{1}{2k}$ **17.** $\dfrac{4}{9}$
19. (a) $A_1 = \$10{,}018.75$
$A_2 \approx \$10{,}037.54$
$A_3 \approx \$10{,}056.36$
$A_4 \approx \$10{,}075.21$
$A_5 \approx \$10{,}094.10$
$A_6 \approx \$10{,}113.03$
$A_7 \approx \$10{,}131.99$
$A_8 \approx \$10{,}150.99$
$A_9 \approx \$10{,}170.02$
$A_{10} \approx \$10{,}189.09$
(b) $12,520.59
21. Arithmetic, $d = -6$ **23.** Not arithmetic
25. $a_n = 12n - 5$ **27.** $a_n = -18n + 150$
29. 4, 21, 38, 55, 72 **31.** 45,450 **33.** 1640
35. $\frac{11{,}300}{3}$ **37.** (a) $51,600 (b) $238,500
39. Geometric, $r = 3$ **41.** Geometric, $r = -3$
43. 2, 30, 450, 6750, 101,250
45. $9, 6, 4, \frac{8}{3}, \frac{16}{9}$ or $9, -6, 4, -\frac{8}{3}, \frac{16}{9}$
47. $a_n = 100(1.05)^{n-1}$; About 155.133
49. $a_n = 18\left(-\frac{1}{2}\right)^{n-1}$; $-\frac{9}{256}$ **51.** 127 **53.** $\frac{15}{16}$
55. 31 **57.** 23.056 **59.** 8 **61.** $\frac{2}{3}$
63. (a) $a_n = 120{,}000(0.7)^n$ (b) $20,168.40
65–67. Proofs **69.** $S_n = n(2n + 7)$; Proof
71. $S_n = \frac{5}{2}\left[1 - \left(\frac{3}{5}\right)^n\right]$; Proof **73.** 2850
75. 5, 10, 15, 20, 25
First differences: 5, 5, 5, 5
Second differences: 0, 0, 0
Linear
77. 15 **79.** 21 **81.** $x^4 + 16x^3 + 96x^2 + 256x + 256$
83. $64 - 240x + 300x^2 - 125x^3$ **85.** 7 **87.** 10,000
89. 120 **91.** 225,792,840 **93.** (a) $\frac{1}{5}$ (b) $\frac{3}{5}$
95. (a) 43% (b) 82% **97.** $\frac{1}{1296}$ **99.** $\frac{3}{4}$
101. False. $\dfrac{(n+2)!}{n!} = \dfrac{(n+2)(n+1)n!}{n!} = (n+2)(n+1)$
103. True by the Properties of Sums.
105. The set of positive integers
107. Each term of the sequence is defined in terms of preceding terms.

Chapter Test *(page 683)*

1. $-\dfrac{1}{5}, \dfrac{1}{8}, -\dfrac{1}{11}, \dfrac{1}{14}, -\dfrac{1}{17}$ **2.** $a_n = \dfrac{n+2}{n!}$
3. 60, 73, 86; 329 **4.** $a_n = -3n + 60$ **5.** $a_n = \frac{7}{2}(2)^n$
6. 86,100 **7.** 477 **8.** 4 **9.** $-\frac{1}{4}$ **10.** Proof
11. $x^4 + 24x^3y + 216x^2y^2 + 864xy^3 + 1296y^4$
12. $3x^5 - 30x^4 + 124x^3 - 264x^2 + 288x - 128$
13. $-22{,}680$ **14.** (a) 72 (b) 328,440

15. (a) 330 (b) 720,720 **16.** 26,000 **17.** 720

18. $\frac{1}{15}$ **19.** $\frac{1}{27{,}405}$ **20.** 10%

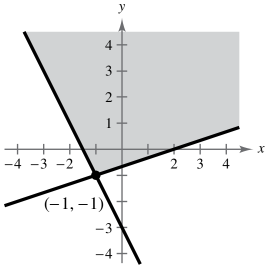
Cumulative Test for Chapters 7–9 *(page 684)*

1. $(1, 2), \left(-\frac{3}{2}, \frac{3}{4}\right)$ **2.** $(-3, -1)$ **3.** $(5, -2, -2)$

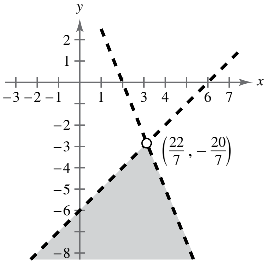
4. $(1, -2, 1)$ **5.** \$0.75 mixture: 120 lb; \$1.25 mixture: 80 lb

6. $y = \frac{1}{4}x^2 - 2x + 6$ **7.** $-\frac{3}{x} + \frac{5x - 1}{x^2 + 2}$

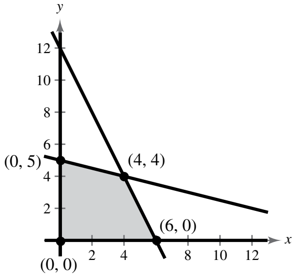
8.



9.



10.



Maximum at $(4, 4)$: 20

Minimum at $(0, 0)$: 0

11. $\begin{bmatrix} -1 & 2 & -1 & \vdots & 9 \\ 2 & -1 & 2 & \vdots & -9 \\ 3 & 3 & -4 & \vdots & 7 \end{bmatrix}$ **12.** $(-2, 3, -1)$

13. $\begin{bmatrix} -3 & 8 \\ 6 & 1 \end{bmatrix}$ **14.** $\begin{bmatrix} 8 & -19 \\ 12 & 9 \end{bmatrix}$ **15.** $\begin{bmatrix} -13 & 6 & -4 \\ 18 & 4 & 4 \end{bmatrix}$

16. Not possible **17.** $\begin{bmatrix} 19 & 3 \\ 6 & 22 \end{bmatrix}$ **18.** $\begin{bmatrix} 28 & 19 \\ -6 & -3 \end{bmatrix}$

19. $\begin{bmatrix} -175 & 37 & -13 \\ 95 & -20 & 7 \\ 14 & -3 & 1 \end{bmatrix}$ **20.** 203

21. $(0, -2), (3, -5), (0, -5)\ (3, -2)$

22. Gym shoes: \$2539 million
Jogging shoes: \$2362 million
Walking shoes: \$4418 million

23. $(-5, 4)$ **24.** $(-3, 4, 2)$ **25.** 9

26. $\frac{1}{5}, -\frac{1}{7}, \frac{1}{9}, -\frac{1}{11}, \frac{1}{13}$ **27.** $a_n = \frac{(n + 1)!}{n + 3}$

28. 1536 **29.** (a) 65.4 (b) $a_n = 3.2n + 1.4$

30. 3, 6, 12, 24, 48 **31.** $\frac{190}{9}$ **32.** Proof

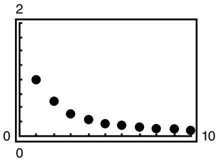
33. $w^4 - 36w^3 + 486w^2 - 2916w + 6561$

34. 2184 **35.** 600 **36.** 70 **37.** 462

38. 453,600 **39.** 151,200 **40.** $\frac{1}{45}$ **41.** $\frac{1}{4}$

Problem Solving *(page 689)*

1. (a)



(b) 0

(c)

n	1	10	100	1000	10,000
a_n	1	0.1089	0.0101	0.0010	0.0001

(d) 0

3. $s_d = \frac{a_1}{1 - r} = \frac{20}{1 - \frac{1}{2}} = 40$

This represents the total distance Achilles ran.

$s_t = \frac{a_1}{1 - r} = \frac{1}{1 - \frac{1}{2}} = 2$

This represents the total amount of time Achilles ran.

5. (a) Arithmetic sequence, difference $= d$
(b) Arithmetic sequence, difference $= dC$
(c) Not an arithmetic sequence

7. (a) 7, 22, 11, 34, 17, 52, 26, 13, 40, 20, 10, 5, 16, 8, 4, 2, 1, 4, 2, 1
(b) $a_1 = 4$: 4, 2, 1, 4, 2, 1, 4, 2, 1, 4
$a_1 = 5$: 5, 16, 8, 4, 2, 1, 4, 2, 1, 4
$a_1 = 12$: 12, 6, 3, 10, 5, 16, 8, 4, 2, 1
Eventually, the terms repeat: 4, 2, 1.

9. Proof **11.** $S_n = \left(\frac{1}{2}\right)^n$; $A_n = \frac{\sqrt{3}}{4}S_n^2$ **13.** $\frac{1}{3}$

15. (a) 3 to 7; 7 to 3 (b) 30 marbles
(c) $P(E) = \frac{\text{odds in favor of } E}{\text{odds in favor of } E + 1}$
(d) Odds in favor of event $E = \frac{P(E)}{P(E')}$

Chapter 10

Section 10.1 *(page 696)*

1. inclination **3.** $\tan \theta = \left|\frac{m_2 - m_1}{1 + m_1 m_2}\right|$ **5.** $\frac{\sqrt{3}}{3}$

7. -1 **9.** $\sqrt{3}$ **11.** 0.4111 **13.** 3.2236

15. -4.1005 **17.** $\frac{\pi}{4}$ rad, 45° **19.** 0.5880 rad, 33.7°

21. $\frac{3\pi}{4}$ rad, 135° **23.** 2.1588 rad, 123.7° **25.** $\frac{\pi}{6}$ rad, 30°

27. $\frac{5\pi}{6}$ rad, 150° **29.** 1.0517 rad, 60.3°

31. 2.1112 rad, 121.0° **33.** 1.6539 rad, 94.8°

35. $\frac{3\pi}{4}$ rad, 135° **37.** $\frac{\pi}{4}$ rad, 45° **39.** $\frac{5\pi}{6}$ rad, 150°

41. 1.2490 rad, 71.6° **43.** 2.4669 rad, 141.3°

45. 1.1071 rad, 63.4° **47.** 0.1974 rad, 11.3°

49. 1.4289 rad, 81.9° **51.** 0.9273 rad, 53.1°

53. 0.8187 rad, 46.9°

55. $(1, 5) \leftrightarrow (4, 5)$: slope $= 0$
$(4, 5) \leftrightarrow (3, 8)$: slope $= -3$
$(3, 8) \leftrightarrow (1, 5)$: slope $= \frac{3}{2}$
$(1, 5)$: 56.3°; $(4, 5)$: 71.6°; $(3, 8)$: 52.1°

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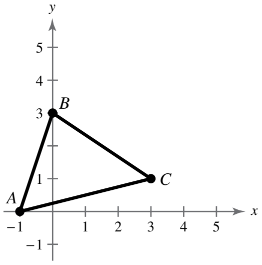
57. $(-4, -1) \leftrightarrow (3, 2)$: slope $= \frac{3}{7}$
$(3, 2) \leftrightarrow (1, 0)$: slope $= 1$
$(1, 0) \leftrightarrow (-4, -1)$: slope $= \frac{1}{5}$
$(-4, -1)$: 11.9°; $(3, 2)$: 21.8°; $(1, 0)$: 146.3°

59. $\frac{\sqrt{2}}{2} \approx 0.7071$ **61.** $\frac{2\sqrt{5}}{5} \approx 0.8944$

63. $2\sqrt{2} \approx 2.8284$ **65.** $\frac{4\sqrt{10}}{5} \approx 2.5298$

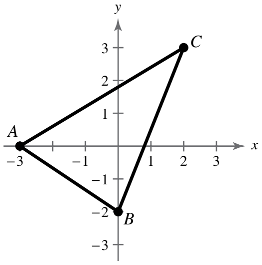
67. 1 **69.** $\frac{1}{5}$

71. (a)



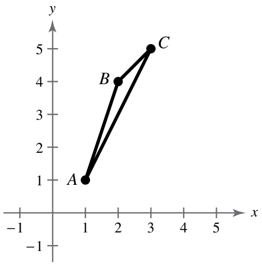
(b) $\frac{11\sqrt{17}}{17}$ (c) $\frac{11}{2}$

73. (a)



(b) $\frac{19\sqrt{34}}{34}$ (c) $\frac{19}{2}$

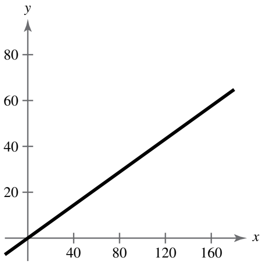
75. (a)



(b) $\frac{\sqrt{5}}{5}$ (c) 1

77. $2\sqrt{2}$ **79.** 0.1003, 1054 ft

81. (a) 0.3456 rad, 19.8° (b) 57.6 ft (c) $y = 0.36x$
(d)

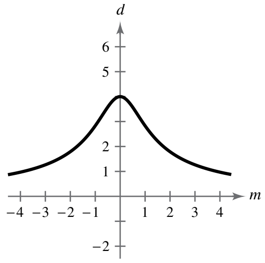


83. True. $\tan 0 = 0$

85. False. Substitute $\tan \theta_1$ and $\tan \theta_2$ for m_1 and m_2 in the formula for the angle between two lines.

87. The inclination of a line measures the angle of intersection (measured counterclockwise) of a line and the x-axis. The angle between two lines is the acute angle of their intersection, which must be less than $\pi/2$.

89. (a) $d = \frac{4}{\sqrt{m^2 + 1}}$
(b)

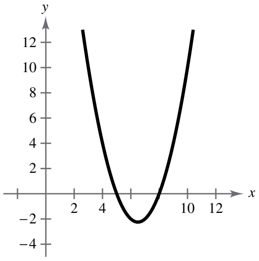


(c) $m = 0$
(d) The graph has a horizontal asymptote of $d = 0$. As the slope becomes larger, the distance between the origin and the line, $y = mx + 4$, becomes smaller and approaches 0.

91. $(x + 5)(x + 7)$ **93.** $(x - 12)(x - 8)$

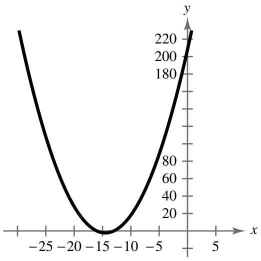
95. $11(x - 4)(x + 1)$

97. $f(x) = \left(x - \frac{13}{2}\right)^2 - \frac{9}{4}$



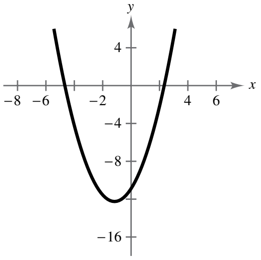
Vertex: $\left(\frac{13}{2}, -\frac{9}{4}\right)$
Axis of Symmetry: $x = \frac{13}{2}$
x-intercepts: $(5, 0)$, $(8, 0)$

99. $f(x) = \left(x + \frac{29}{2}\right)^2 - \frac{9}{4}$



Vertex: $\left(-\frac{29}{2}, -\frac{9}{4}\right)$
Axis of Symmetry: $x = -\frac{29}{2}$
x-intercepts: $(-16, 0)$, $(-13, 0)$

101. $f(x) = \left(x + \frac{7}{6}\right)^2 - \frac{49}{4}$



Vertex: $\left(-\frac{7}{6}, -\frac{49}{4}\right)$
Axis of Symmetry: $x = -\frac{7}{6}$
x-intercepts: $\left(-\frac{14}{3}, 0\right)$, $\left(\frac{7}{3}, 0\right)$

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103. (a) $\sqrt{34}$
(b) $\left(\frac{13}{2}, \frac{33}{2}\right)$

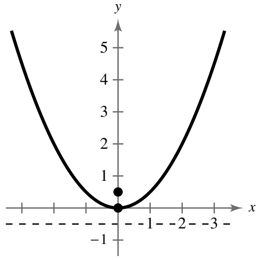
105. (a) $\sqrt{445}$
(b) $\left(-18, \frac{1}{2}\right)$

107. (a) $\frac{\sqrt{74}}{7}$ (b) $\left(1, -\frac{15}{14}\right)$

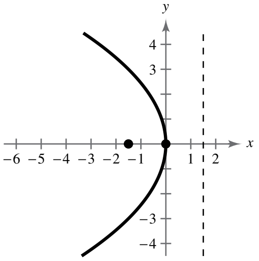
Section 10.2 *(page 704)*

1. conic **3.** parabola; directrix; focus **5.** Focal chord
7. Find the midpoint between the focus and the directrix.
9. c **10.** a **11.** b **12.** d
13. $x^2 = 4y$ **15.** $x^2 = 2y$ **17.** $y^2 = -8x$
19. $x^2 = -8y$ **21.** $y^2 = 4x$ **23.** $x^2 = \frac{8}{3}y$
25. $y^2 = -\frac{25}{2}x$ **27.** $y^2 = 4(x + 4)$
29. $(y - 3)^2 = -8(x - 6)$ **31.** $x^2 = -8(y - 2)$
33. $(y - 2)^2 = 8x$ **35.** $(x - 3)^2 = 3(y + 3)$

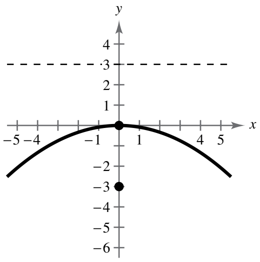
37. Vertex: $(0, 0)$
Focus: $\left(0, \frac{1}{2}\right)$
Directrix: $y = -\frac{1}{2}$



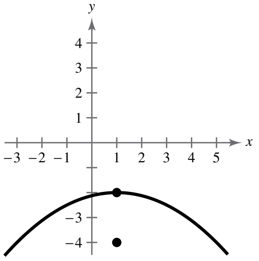
39. Vertex: $(0, 0)$
Focus: $\left(-\frac{3}{2}, 0\right)$
Directrix: $x = \frac{3}{2}$



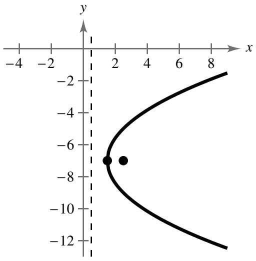
41. Vertex: $(0, 0)$
Focus: $(0, -3)$
Directrix: $y = 3$



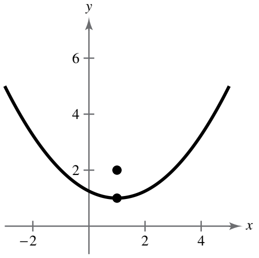
43. Vertex: $(1, -2)$
Focus: $(1, -4)$
Directrix: $y = 0$



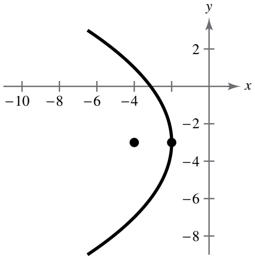
45. Vertex: $\left(\frac{3}{2}, -7\right)$
Focus: $\left(\frac{5}{2}, -7\right)$
Directrix: $x = \frac{1}{2}$



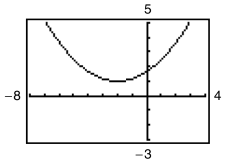
47. Vertex: $(1, 1)$
Focus: $(1, 2)$
Directrix: $y = 0$



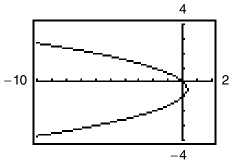
49. Vertex: $(-2, -3)$
Focus: $(-4, -3)$
Directrix: $x = 0$



51. Vertex: $(-2, 1)$
Focus: $\left(-2, \frac{5}{2}\right)$
Directrix: $y = -\frac{1}{2}$



53. Vertex: $\left(\frac{1}{4}, -\frac{1}{2}\right)$
Focus: $\left(0, -\frac{1}{2}\right)$
Directrix: $x = \frac{1}{2}$

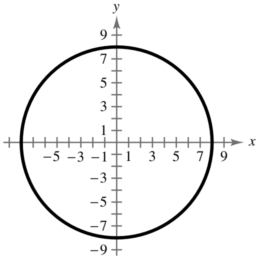


55. $y = \frac{3}{2}x - \frac{9}{2}$ **57.** $y = -4x - 8$
59. $y = 4x + 2$ **61.** $y^2 = 6x$ **63.** $y^2 = 640x$
65. (a) $x^2 = 12{,}288y$ (in feet) (b) About 22.6 ft
67. $x^2 = -\frac{25}{4}(y - 48)$ **69.** About 19.6 m
71. (a) $(0, 45)$ (b) $y = \frac{1}{180}x^2$
73. (a) $17{,}500\sqrt{2}$ mi/h ≈ 24,750 mi/h
(b) $x^2 = -16{,}400(y - 4100)$
75. (a) $x^2 = -49(y - 100)$ (b) 70 ft
77. False. If the graph crossed the directrix, then there would exist points closer to the directrix than the focus.

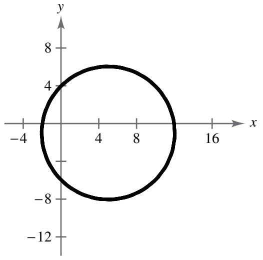
79. Slope: $m = \frac{x_1}{2p}$
x-intercept: $\left(\frac{x_1^2 - 2py_1}{x_1}, 0\right)$
y-intercept: $\left(0, \frac{2py_1 - x_1^2}{2p}\right)$

81. Both (a) and (b) are parabolas with vertical axes, while (c) is a parabola with a horizontal axis. Equations (a) and (b) are equivalent when $p = 1/(4a)$.

83. Center: $(0, 0)$, $r = 8$



85. Center: $(5, -1)$, $r = 5\sqrt{2}$



87. $2x^3, x \neq 0$ **89.** $\frac{16b^8}{a^{12}}, b \neq 0$
91. $y = (x - 4)^2 + 2$ **93.** $y = |-x + 3| - 1$

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Section 10.3 *(page 714)*

1. ellipse; foci **3.** Major axis, minor axis; major axis

5. b **6.** c **7.** a **8.** d

9. $\frac{x^2}{2^2} + \frac{y^2}{4^2} = 1$ **11.** $\frac{x^2}{7^2} + \frac{y^2}{(\sqrt{45})^2} = 1$

13. $\frac{x^2}{5^2} + \frac{y^2}{3^2} = 1$ **15.** $\frac{x^2}{3^2} + \frac{y^2}{6^2} = 1$

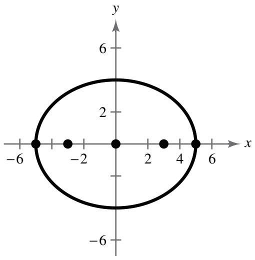
17. $\frac{x^2}{6^2} + \frac{y^2}{(3/\sqrt{5})^2} = 1$ **19.** $\frac{(x-2)^2}{1^2} + \frac{(y-3)^2}{3^2} = 1$

21. $\frac{(x-6)^2}{4^2} + \frac{y^2}{2^2} = 1$ **23.** $\frac{x^2}{(\sqrt{48})^2} + \frac{(y-4)^2}{8^2} = 1$

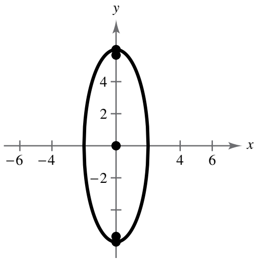
25. $\frac{(x-1)^2}{3^2} + \frac{(y-3)^2}{2^2} = 1$ **27.** $\frac{(x-1)^2}{(\sqrt{12})^2} + \frac{(y-4)^2}{4^2} = 1$

29. $\frac{(x-2)^2}{2^2} + \frac{(y-2)^2}{1^2} = 1$

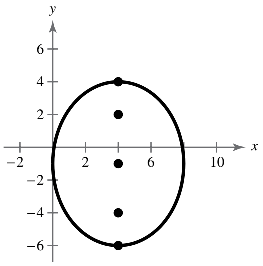
31. Center: $(0, 0)$
Vertices: $(\pm 5, 0)$
Foci: $(\pm 3, 0)$
Eccentricity: $\frac{3}{5}$



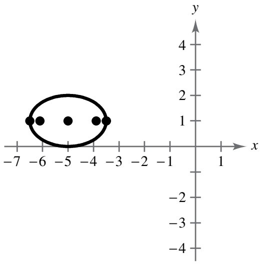
33. Center: $(0, 0)$
Vertices: $(0, \pm 6)$
Foci: $(0, \pm 4\sqrt{2})$
Eccentricity: $\frac{2\sqrt{2}}{3}$



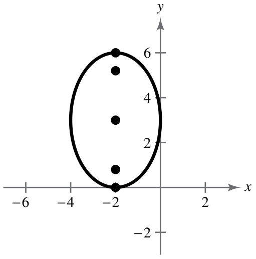
35. Center: $(4, -1)$
Vertices: $(4, -6), (4, 4)$
Foci: $(4, 2), (4, -4)$
Eccentricity: $\frac{3}{5}$



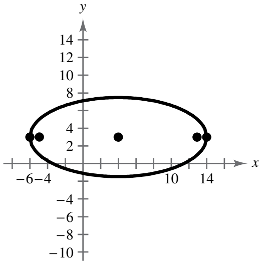
37. Center: $(-5, 1)$
Vertices: $\left(-\frac{7}{2}, 1\right), \left(-\frac{13}{2}, 1\right)$
Foci: $\left(-5 \pm \frac{\sqrt{5}}{2}, 1\right)$
Eccentricity: $\frac{\sqrt{5}}{3}$



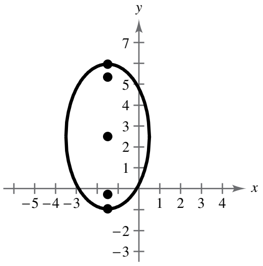
39. Center: $(-2, 3)$
Vertices: $(-2, 6), (-2, 0)$
Foci: $(-2, 3 \pm \sqrt{5})$
Eccentricity: $\frac{\sqrt{5}}{3}$



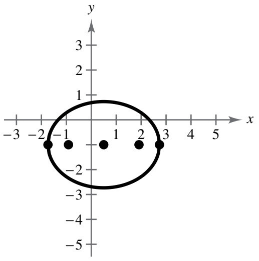
41. Center: $(4, 3)$
Vertices: $(14, 3), (-6, 3)$
Foci: $(4 \pm 4\sqrt{5}, 3)$
Eccentricity: $\frac{2\sqrt{5}}{5}$



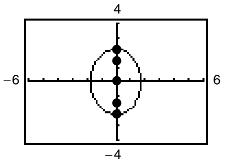
43. Center: $\left(-\frac{3}{2}, \frac{5}{2}\right)$
Vertices: $\left(-\frac{3}{2}, \frac{5}{2} \pm 2\sqrt{3}\right)$
Foci: $\left(-\frac{3}{2}, \frac{5}{2} \pm 2\sqrt{2}\right)$
Eccentricity: $\frac{\sqrt{6}}{3}$



45. Center: $\left(\frac{1}{2}, -1\right)$
Vertices: $\left(\frac{1}{2} \pm \sqrt{5}, -1\right)$
Foci: $\left(\frac{1}{2} \pm \sqrt{2}, -1\right)$
Eccentricity: $\frac{\sqrt{10}}{5}$

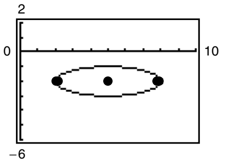


47.



Center: $(0, 0)$
Vertices: $(0, \pm\sqrt{5})$
Foci: $(0, \pm\sqrt{2})$

49.



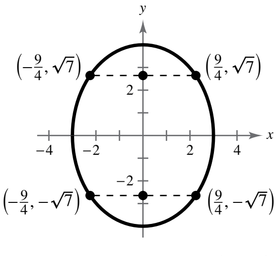
Center: $(5, -2)$
Vertices: $(2, -2), (8, -2)$
Foci: $(5 \pm 2\sqrt{2}, -2)$

51. $\frac{x^2}{25} + \frac{y^2}{16} = 1$ **53.** $\frac{(x-1)^2}{45} + \frac{(y-7)^2}{81} = 1$

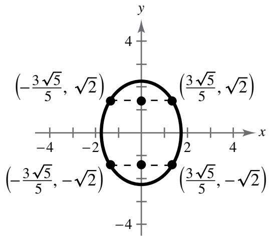
55. (a) $\frac{x^2}{2352.25} + \frac{y^2}{529} = 1$ (b) About 85.4 ft

57. About 229.8 mm **59.** $e \approx 0.0520$

61.



63.



65. False. The graph of $(x^2/4) + y^4 = 1$ is not an ellipse. The degree of y is 4, not 2.

67. $\frac{(x-6)^2}{324} + \frac{(y-2)^2}{308} = 1$ **69.** Proof

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71. $f(x) = (x - 3)^2$ **73.** $B = 67°, b \approx 11.45, c \approx 8.00$
75. $A \approx 98.25°, B \approx 48.80°, C \approx 32.96°$
77. $(2, -6)$ **79.** No solution

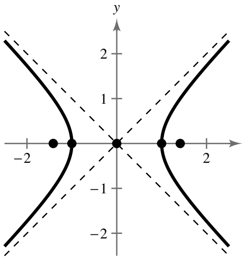
Section 10.4 *(page 724)*

1. hyperbola; foci **3.** transverse axis; center
5. Center **7.** b **8.** d **9.** c **10.** a

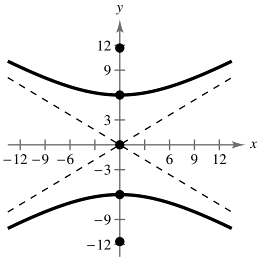
11. $\dfrac{y^2}{2^2} - \dfrac{x^2}{(\sqrt{12})^2} = 1$ **13.** $\dfrac{(y-5)^2}{4^2} - \dfrac{(x-4)^2}{3^2} = 1$

15. $\dfrac{y^2}{3^2} - \dfrac{(x-2)^2}{(3/2)^2} = 1$ **17.** $\dfrac{(x-2)^2}{2^2} - \dfrac{(y+3)^2}{(\sqrt{8})^2} = 1$

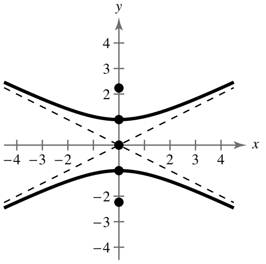
19. Center: $(0, 0)$
Vertices: $(\pm 1, 0)$
Foci: $(\pm\sqrt{2}, 0)$
Asymptotes: $y = \pm x$



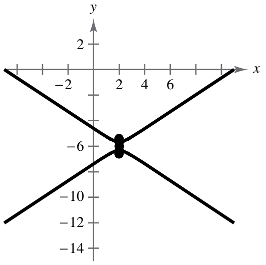
21. Center: $(0, 0)$
Vertices: $(0, \pm 6)$
Foci: $(0 \pm 2\sqrt{34})$
Asymptotes: $y = \pm\frac{3}{5}x$



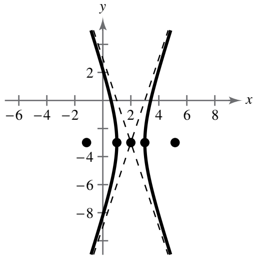
23. Center: $(0, 0)$
Vertices: $(0, \pm 1)$
Foci: $(0, \pm\sqrt{5})$
Asymptotes: $y = \pm\frac{1}{2}x$



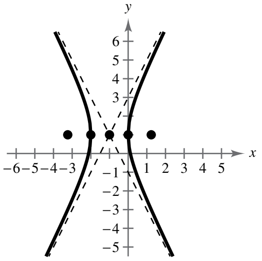
25. Center: $(2, -6)$
Vertices: $\left(2, -\dfrac{17}{3}\right), \left(2, -\dfrac{19}{3}\right)$
Foci: $\left(2, -6 \pm \dfrac{\sqrt{13}}{6}\right)$
Asymptotes: $y = -6 \pm \dfrac{2}{3}(x - 2)$



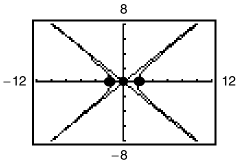
27. Center: $(2, -3)$
Vertices: $(3, -3), (1, -3)$
Foci: $(2 \pm \sqrt{10}, -3)$
Asymptotes:
$y = -3 \pm 3(x - 2)$



29. Center: $(-1, 1)$
Vertices: $(-2, 1), (0, 1)$
Foci: $(-1 \pm \sqrt{5}, 1)$
Asymptotes:
$y = 1 \pm 2(x + 1)$

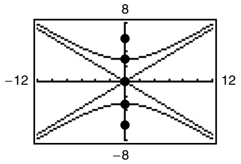


31.



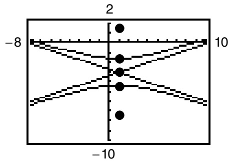
Center: $(0, 0)$
Vertices: $(\pm\sqrt{3}, 0)$
Foci: $(\pm\sqrt{5}, 0)$

33.



Center: $(0, 0)$
Vertices: $(0, \pm 3)$
Foci: $(0, \pm\sqrt{34})$

35.



Center: $(1, -3)$
Vertices: $(1, -3 \pm \sqrt{2})$
Foci: $(1, -3 \pm 2\sqrt{5})$

37. $\dfrac{x^2}{1^2} - \dfrac{y^2}{5^2} = 1$ **39.** $\dfrac{y^2}{(32/\sqrt{17})^2} - \dfrac{x^2}{(8/\sqrt{17})^2} = 1$

41. $\dfrac{(x-2)^2}{1^2} - \dfrac{(y-2)^2}{1^2} = 1$ **43.** $\dfrac{(y-2)^2}{2^2} - \dfrac{(x-3)^2}{3^2} = 1$

45. $\dfrac{(x-4)^2}{4^2} - \dfrac{(y+1)^2}{3^2} = 1$ **47.** Ellipse **49.** Hyperbola

51. Ellipse **53.** Parabola **55.** Circle

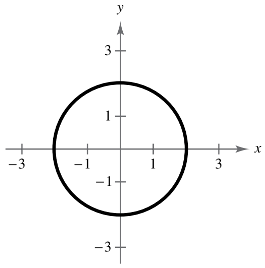
57. $\dfrac{x^2}{98{,}010{,}000} - \dfrac{y^2}{13{,}503{,}600} = 1$

59. (a) $x \approx 110.3$ mi (b) 57.0 mi (c) $y = \dfrac{27\sqrt{19}}{93}x$

61. True. For a hyperbola, $c^2 = a^2 + b^2$. The larger the ratio of b to a, the larger the eccentricity of the hyperbola, $e = c/a$.

63. False. The graph is two intersecting lines.

65.



(a) $C > 2$ and $C < -\frac{17}{4}$
(b) $C = 2$
(c) $-2 < C < 2, C = -\frac{17}{4}$
(d) $C = -2$
(e) $-\frac{17}{4} < C < -2$

67. The equations of the asymptotes should be $y = k \pm \dfrac{a}{b}(x - h)$.

69. $-3, 5$ **71.** $8 \pm 2\sqrt{3}$ **73.** $\dfrac{7 \pm \sqrt{11}}{3}$

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75. $\dfrac{-9 \pm \sqrt{53}}{2}$ **77.** $-10 \pm \sqrt{87}$ **79.** $\dfrac{-3 \pm \sqrt{57}}{8}$

81. Proof **83.** $\dfrac{\pi}{8}, \dfrac{5\pi}{8}, \dfrac{9\pi}{8}, \dfrac{13\pi}{8}$ **85.** $\dfrac{\pi}{6}, \dfrac{\pi}{2}, \dfrac{3\pi}{2}, \dfrac{5\pi}{6}, \dfrac{7\pi}{6}, \dfrac{11\pi}{6}$

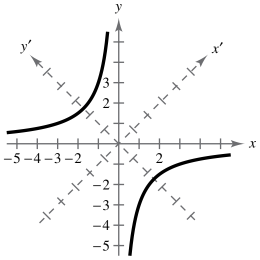
Section 10.5 *(page 733)*

1. rotation; axes

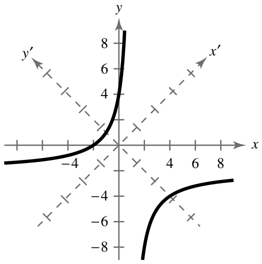
3. $A'(x')^2 + C'(y')^2 + D'x' + E'y' + F' = 0$ **5.** $(0, -2)$

7. $\left(\dfrac{3+\sqrt{3}}{2}, \dfrac{3\sqrt{3}-1}{2}\right)$ **9.** $\left(\dfrac{3\sqrt{2}}{2}, -\dfrac{\sqrt{2}}{2}\right)$

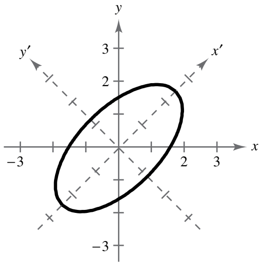
11. $\left(\dfrac{-1+2\sqrt{3}}{2}, \dfrac{2+\sqrt{3}}{2}\right)$ **13.** $\dfrac{(y')^2}{6} - \dfrac{(x')^2}{6} = 1$



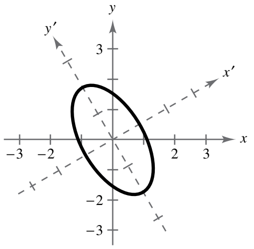
15. $\dfrac{\left(y' + \dfrac{3\sqrt{2}}{2}\right)^2}{12} - \dfrac{\left(x' + \dfrac{\sqrt{2}}{2}\right)^2}{12} = 1$



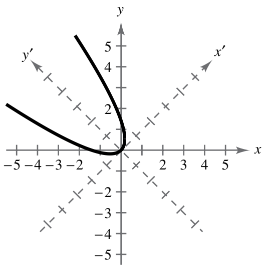
17. $\dfrac{(x')^2}{6} + \dfrac{(y')^2}{3/2} = 1$



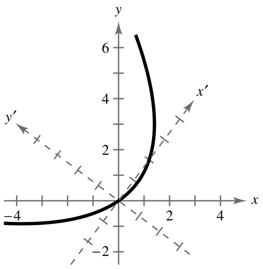
19. $\dfrac{(x')^2}{1} + \dfrac{(y')^2}{4} = 1$



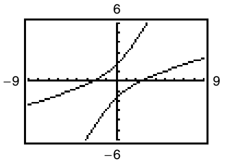
21. $(x')^2 = y'$



23. $(x' - 1)^2 = 6\left(y' + \frac{1}{6}\right)$

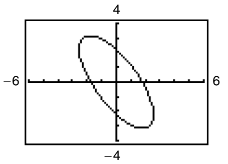


25.



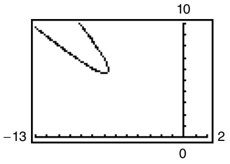
$\theta \approx 37.98°$

27.



$\theta \approx 36.32°$

29.



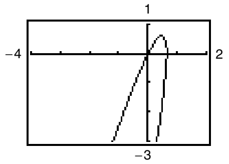
$\theta = 45°$

31. e **32.** a **33.** d **34.** c **35.** f **36.** b

37. (a) Parabola

(b) $y = \dfrac{(8x-5) \pm \sqrt{(8x-5)^2 - 4(16x^2 - 10x)}}{2}$

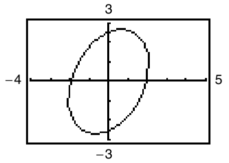
(c)



39. (a) Ellipse

(b) $y = \dfrac{6x \pm \sqrt{36x^2 - 28(12x^2 - 45)}}{14}$

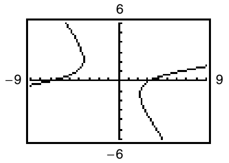
(c)



41. (a) Hyperbola

(b) $y = \dfrac{6x \pm \sqrt{36x^2 + 20(x^2 + 4x - 22)}}{-10}$

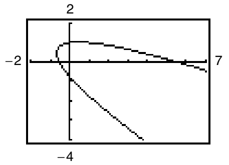
(c)



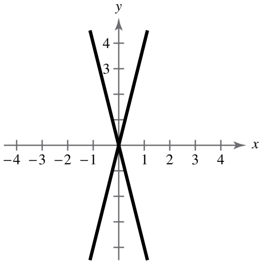
43. (a) Parabola

(b) $y = \dfrac{-(4x-1) \pm \sqrt{(4x-1)^2 - 16(x^2 - 5x - 3)}}{8}$

(c)



45.



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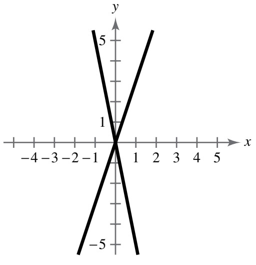

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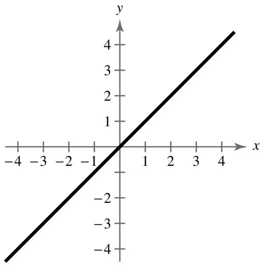
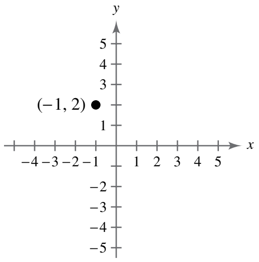
49.



51.



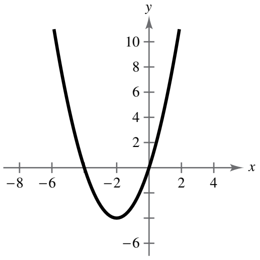
53. $(\sqrt{2}, \sqrt{2}), (-\sqrt{2}, -\sqrt{2})$

55. (a) $(y' + 9)^2 = 9(x' - 12)$ (b) 2.25 ft

57. True. The graph of the equation can be classified by finding the discriminant. For a graph to be a hyperbola, the discriminant must be greater than zero. If $k \geq \frac{1}{4}$, then the discriminant would be less than or equal to zero.

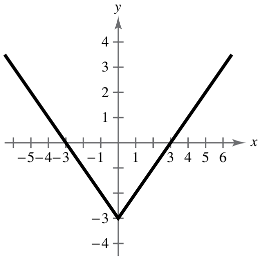
59. Answers will vary.

61. No symmetry



Intercepts: $(-4, 0), (0, 0)$

63. y-axis symmetry



Intercepts: $(-3, 0), (3, 0), (0, -3)$

65. $\cot x$ **67.** 1 **69.** $(3a, a - 3, a)$

Section 10.6 *(page 741)*

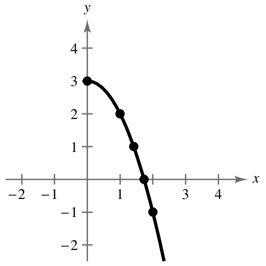
1. plane curve

3. Solve for t in one equation. Then substitute for t in the other equation. The result is the rectangular equation.

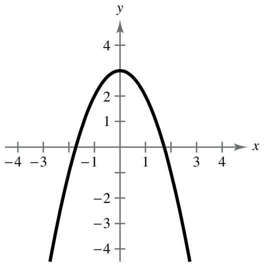
5. (a)

t	0	1	2	3	4
x	0	1	$\sqrt{2}$	$\sqrt{3}$	2
y	3	2	1	0	−1

(b)

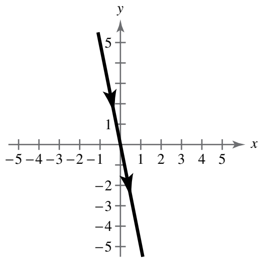


(c)



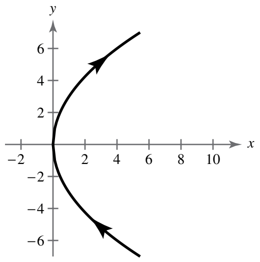
The graph of $y = 3 - x^2$ shows the entire parabola rather than just the right half.

7.



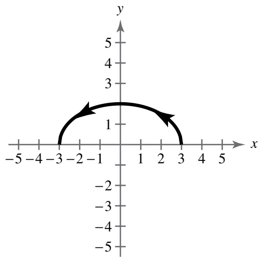
The curve is traced from left to right.

9.



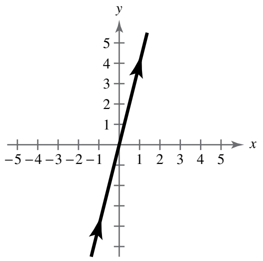
The curve is traced clockwise.

11.



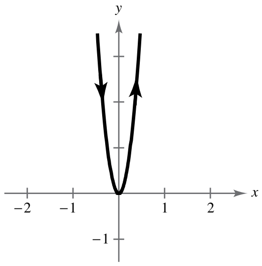
The curve is traced from right to left.

13. (a)



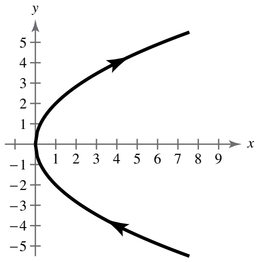
(b) $y = 4x$

15. (a)



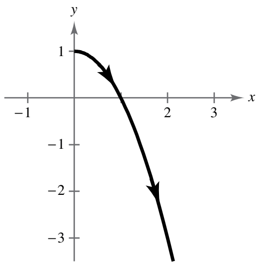
(b) $y = 16x^2$

17. (a)



(b) $y = \pm 2\sqrt{x}$

19. (a)



(b) $y = 1 - x^2,\ x \geq 0$

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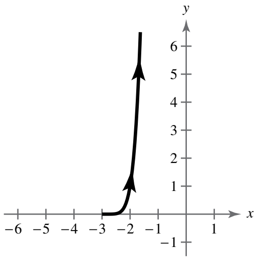
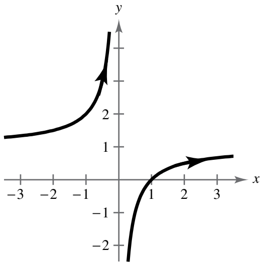
21. (a)



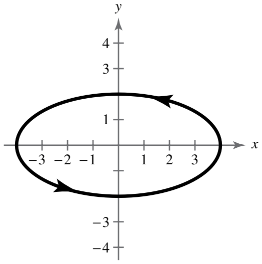
(b) $y = (x + 3)^6,\ x \geq -3$

23. (a)



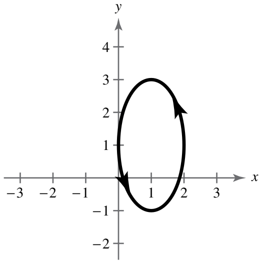
(b) $y = \dfrac{(x - 1)}{x}$

25. (a)



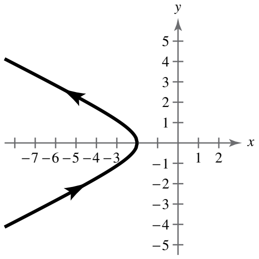
(b) $\dfrac{x^2}{16} + \dfrac{y^2}{4} = 1$

27. (a)



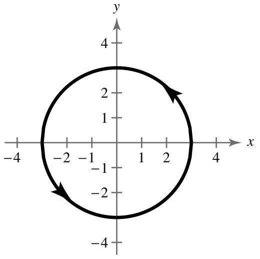
(b) $\dfrac{(x - 1)^2}{1} + \dfrac{(y - 1)^2}{4} = 1$

29. (a)



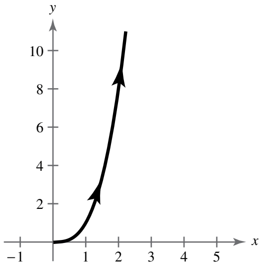
(b) $\dfrac{x^2}{4} - y^2 = 1,\ x \leq -2$

31. (a)



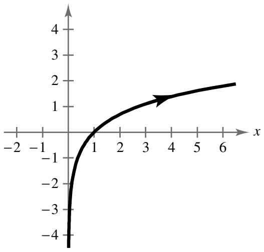
(b) $x^2 + y^2 = 9$

33. (a)



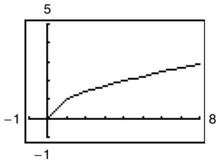
(b) $y = x^3,\ x > 0$

35. (a)

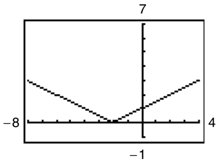


(b) $y = \ln x$

37.



39.



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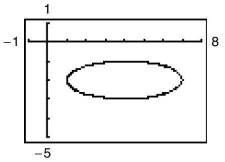
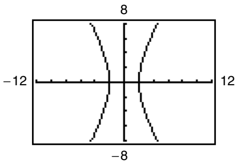


43.



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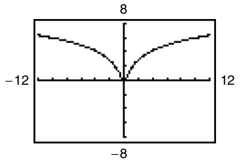


47. Each curve represents a portion of the line $y = 2x + 1$.

	Domain	**Orientation**
(a)	$(-\infty, \infty)$	Left to right
(b)	$[-1, 1]$	Depends on θ
(c)	$(0, \infty)$	Right to left
(d)	$(0, \infty)$	Left to right

49. $y - y_1 = m(x - x_1)$

51. $\dfrac{(x - h)^2}{a^2} + \dfrac{(y - k)^2}{b^2} = 1$

53. $x = 3t$
$y = 6t$

55. $x = 3 + 4 \cos \theta$
$y = 2 + 4 \sin \theta$

57. $x = 5 \cos \theta$
$y = 3 \sin \theta$

59. $x = 5 + 4 \sec \theta$
$y = 3 \tan \theta$

61. $x = -5t$
$y = 2t$
$0 \leq t \leq 1$

63. $x = 3 \sec \theta$
$y = 4 \tan \theta$
$\dfrac{\pi}{2} < \theta < \dfrac{3\pi}{2}$

65. (a) $x = t,\ y = 3t - 2$ (b) $x = -t + 2,\ y = -3t + 4$

67. (a) $x = t,\ y = \frac{1}{2}(t - 1)$ (b) $x = -t + 2,\ y = -\frac{1}{2}(t - 1)$

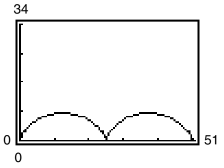
69. (a) $x = t,\ y = t^2 + 1$ (b) $x = -t + 2,\ y = t^2 - 4t + 5$

71. (a) $x = t,\ y = 1 - 2t^2$
(b) $x = 2 - t,\ y = -2t^2 + 8t - 7$

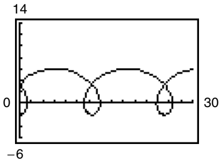
73. (a) $x = t,\ y = \dfrac{1}{t}$ (b) $x = -t + 2,\ y = -\dfrac{1}{t - 2}$

75. (a) $x = t,\ y = e^t$ (b) $x = -t + 2,\ y = e^{-t+2}$

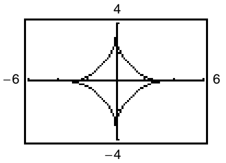
77.



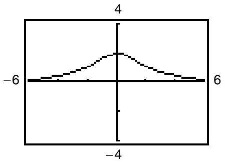
79.



81.



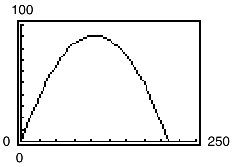
83.



85. b
Domain: $[-2, 2]$
Range: $[-1, 1]$

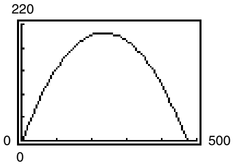
87. d
Domain: $(-\infty, \infty)$
Range: $(-\infty, \infty)$

89. (a)



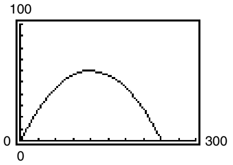
Maximum height: 90.7 ft
Range: 209.6 ft

(b)



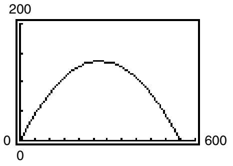
Maximum height: 204.2 ft
Range: 471.6 ft

(c)



Maximum height: 60.5 ft
Range: 242.0 ft

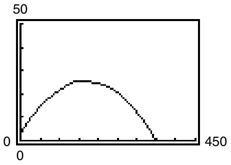
(d)



Maximum height: 136.1 ft
Range: 544.5 ft

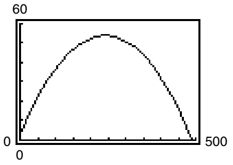
91. (a) $x = (146.67 \cos \theta)t$
$y = 3 + (146.67 \sin \theta)t - 16t^2$

(b)



No

(c)



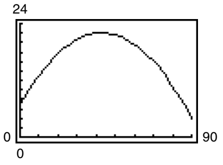
Yes

(d) 19.3°

93. (a) $x = (\cos 35^\circ)v_0 t$
$y = 7 + (\sin 35^\circ)v_0 t - 16t^2$

(b) About 54.09 ft/sec

(c)



22.04 ft (d) About 2.03 sec

95. $x = a\theta - b \sin \theta$
$y = a - b \cos \theta$

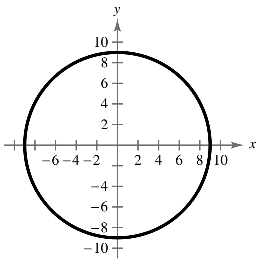
97. True
$x = t$
$y = t^2 + 1 \implies y = x^2 + 1$
$x = 3t$
$y = 9t^2 + 1 \implies y = x^2 + 1$

99. False. The parametric equations $x = t^2$ and $y = t$ give the rectangular equation $x = y^2$, so y is not a function of x.

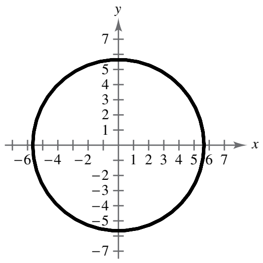
101. The parametric equation for x is defined only when $t \geq 1$, so the domain of the rectangular equation is $x \geq 0$.

103. Parametric equations are useful when graphing two functions simultaneously on the same coordinate system. For example, they are useful when tracking the path of an object so that the position and the time associated with that position can be determined.

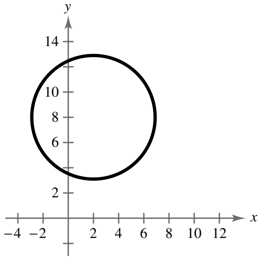
105. Center: $(0, 0)$, $r = 9$



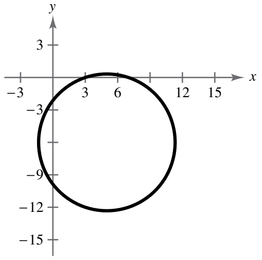
107. Center: $(0, 0)$, $r = 4\sqrt{2}$



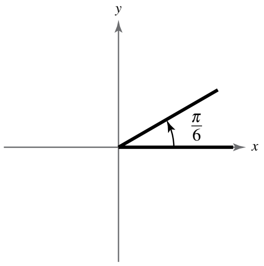
109. Center: $(2, 8)$, $r = 2\sqrt{6}$



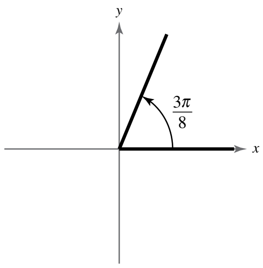
111. Center: $(5, -6)$, $r = 2\sqrt{10}$



113. *Sample Answer:* $-\frac{11\pi}{6}, \frac{13\pi}{6}$



115. *Sample Answer:* $-\frac{13\pi}{8}, \frac{19\pi}{8}$



117. $\frac{4\pi}{3}, \frac{5\pi}{3}$

119. $\frac{\pi}{3}, \frac{4\pi}{3}$

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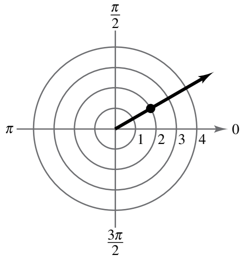
Section 10.7 *(page 749)*

1. pole

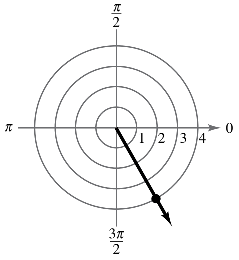
3. $x = r\cos\theta,\ y = r\sin\theta,\ \tan\theta = \dfrac{y}{x},\ r^2 = x^2 + y^2$

5.



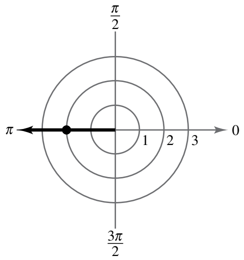
$\left(2, -\dfrac{11\pi}{6}\right), \left(-2, -\dfrac{5\pi}{6}\right), \left(-2, \dfrac{7\pi}{6}\right)$

7.



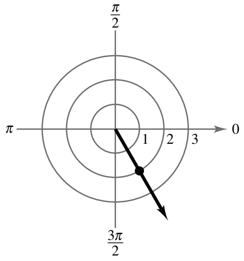
$\left(4, \dfrac{5\pi}{3}\right), \left(-4, \dfrac{2\pi}{3}\right), \left(-4, -\dfrac{4\pi}{3}\right)$

9.



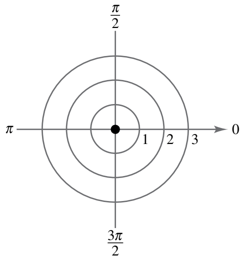
$(2, \pi), (-2, 0), (2, -\pi)$

11.



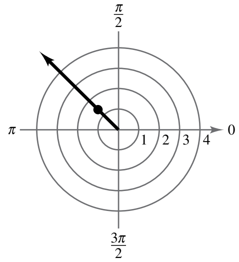
$\left(-2, -\dfrac{4\pi}{3}\right), \left(2, -\dfrac{\pi}{3}\right), \left(2, \dfrac{5\pi}{3}\right)$

13.



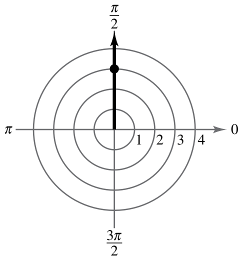
Sample answer: $\left(0, -\dfrac{11\pi}{6}\right), \left(0, -\dfrac{5\pi}{6}\right), \left(0, \dfrac{\pi}{6}\right)$

15.



$\left(\sqrt{2}, -3.92\right), \left(-\sqrt{2}, -0.78\right), \left(-\sqrt{2}, 5.50\right)$

17.



$(-3, 4.71), (3, 1.57), (3, -4.71)$

19. $(0, 0)$ **21.** $(0, 3)$ **23.** $\left(-\sqrt{2}, \sqrt{2}\right)$ **25.** $\left(\sqrt{3}, 1\right)$

27. $\left(-\dfrac{3}{2}, \dfrac{3\sqrt{3}}{2}\right)$ **29.** $(-1.85, 0.77)$ **31.** $(0.26, 0.97)$

33. $(-1.13, -2.23)$ **35.** $(-2.43, -0.60)$

37. $(0.20, -3.09)$ **39.** $\left(\sqrt{2}, \dfrac{\pi}{4}\right)$ **41.** $\left(3\sqrt{2}, \dfrac{5\pi}{4}\right)$

43. $(3, 0)$ **45.** $\left(5, \dfrac{3\pi}{2}\right)$ **47.** $\left(\sqrt{6}, \dfrac{5\pi}{4}\right)$ **49.** $\left(2, \dfrac{11\pi}{6}\right)$

51. $(3.61, 5.70)$ **53.** $(5.39, 2.76)$ **55.** $(4.36, -1.98)$

57. $(2.83, 0.49)$ **59.** $r = 3$ **61.** $\theta = \dfrac{\pi}{4}$

63. $r = 10\sec\theta$ **65.** $r = \dfrac{-2}{3\cos\theta - \sin\theta}$

67. $r^2 = 16\sec\theta\csc\theta = 32\csc 2\theta$

69. $r = a\sec\theta$ **71.** $r = a$ **73.** $r = 2a\cos\theta$

75. $r^2 = \cos 2\theta$ **77.** $r = \cot^2\theta\csc\theta$

79. $x^2 + y^2 = 25$ **81.** $\sqrt{3}x + y = 0$ **83.** $y = 4$

85. $x^2 + y^2 + 2x = 0$ **87.** $x^2 + y^2 - x^{2/3} = 0$

89. $(x^2 + y^2)^2 = 6x^2y - 2y^3$ **91.** $4x^2 - 5y^2 - 36y - 36 = 0$

93. The graph consists of all points six units from the pole; $x^2 + y^2 = 36$

95. The graph consists of all points on the line that makes an angle of $\pi/6$ with the polar axis and passes through the pole; $-\sqrt{3}x + 3y = 0$

97. The graph is a vertical line; $x - 3 = 0$

99. The graph is a circle with center $(0, 1)$ and radius 1; $x^2 + (y - 1)^2 = 1$

101. (a) $r = 30$

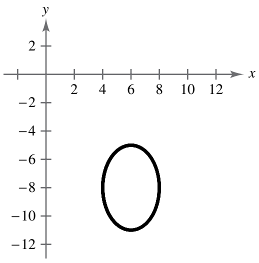
(b) $\left(30, \dfrac{5\pi}{6}\right)$; 30 represents the distance of the passenger car from the center, and $\dfrac{5\pi}{6} = 150°$ represents the angle to which the car has rotated.

(c) $(-25.98, 15)$; The car is about 25.98 feet to the left of the center and 15 feet above the center.

103. True. Because r is a directed distance, the point (r, θ) can be represented as $(r, \theta \pm 2\pi n)$.

105. $\left(1, -\sqrt{3}\right)$ is in Quadrant IV, so $\theta = -\dfrac{\pi}{3}$. **107.** $(5, 0)$

109.



The curve is traced clockwise.

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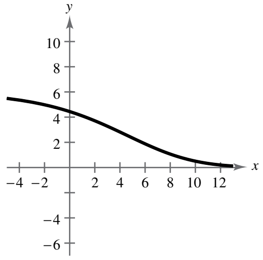
111.



The curve is traced from left to right.

Section 10.8 *(page 757)*

1. lemniscate

3. Determine whether replacing (r, θ) with $(r, \pi - \theta)$ or $(-r, -\theta)$ yields an equivalent equation.

5. Circle **7.** Limaçon with inner loop

9. Rose curve with four petals **11.** Polar axis

13. $\theta = \frac{\pi}{2}$ **15.** $\theta = \frac{\pi}{2}$, polar axis, pole

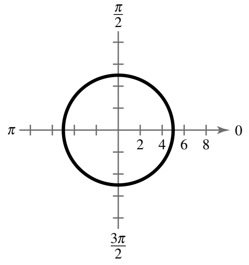
17. Maximum: $|r| = 20$ when $\theta = \frac{3\pi}{2}$

Zero: $r = 0$ when $\theta = \frac{\pi}{2}$

19. Maximum: $|r| = 4$ when $\theta = 0, \frac{\pi}{3}, \frac{2\pi}{3}$

Zeros: $r = 0$ when $\theta = \frac{\pi}{6}, \frac{\pi}{2}, \frac{5\pi}{6}$

21.



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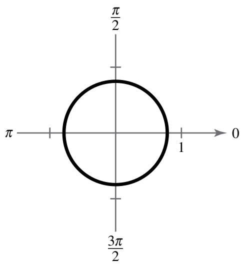

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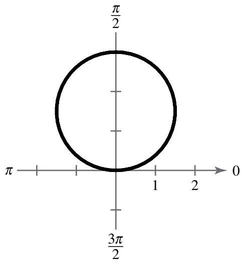

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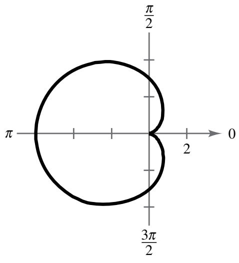

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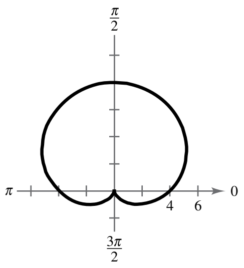

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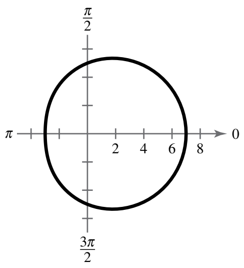

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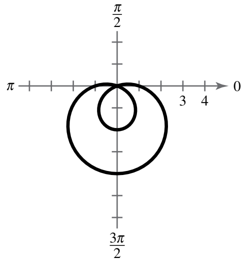

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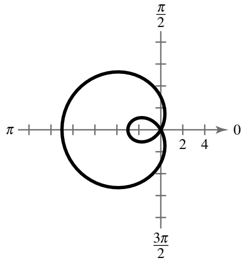

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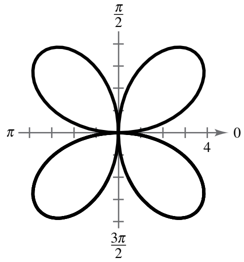

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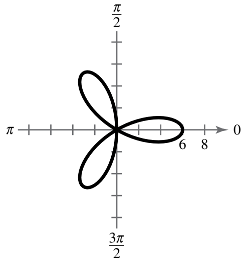

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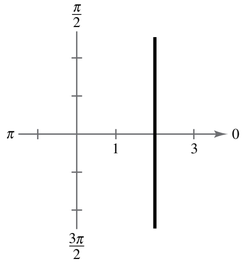

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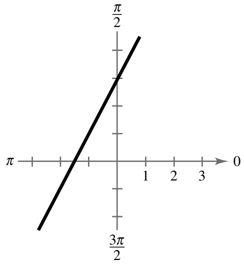

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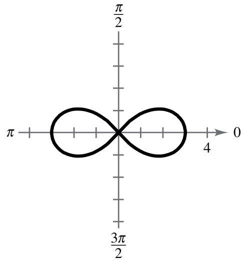

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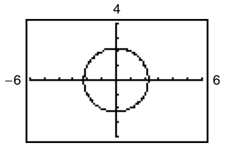

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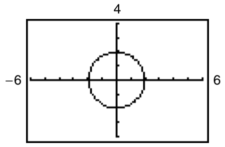

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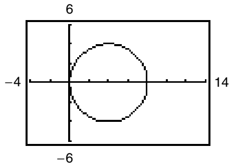

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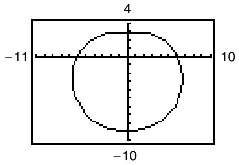

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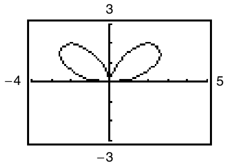

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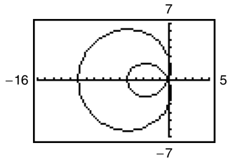
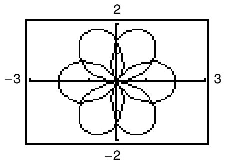


$0 \le \theta < 2\pi$

59.



$0 \le \theta < 4\pi$

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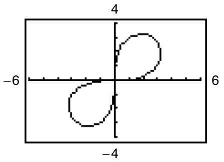
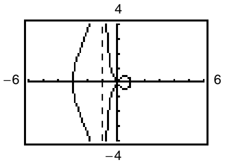
61.



$0 \le \theta < \frac{\pi}{2}$

63.



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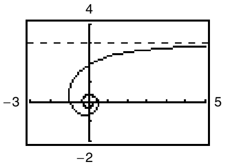
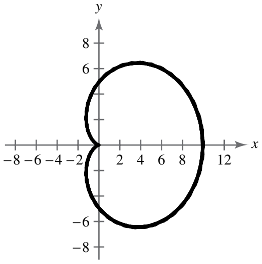


67. (a)



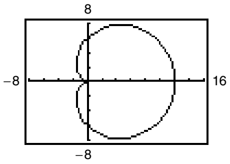
Cardioid

(b) 0 radians

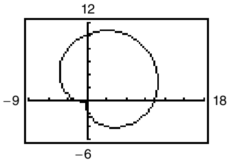
69. True. The equation is of the form $r = a \sin n\theta$, where n is odd.

71. Answers will vary.

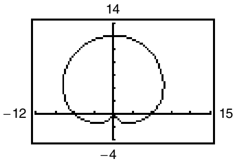
73. (a)



(b)



(c)



The angle ϕ controls rotation of the axis of symmetry. $r = 6(1 + \sin \theta)$

75. (a) $r = 2 - \frac{\sqrt{2}}{2}(\sin \theta - \cos \theta)$

(b) $r = 2 + \cos \theta$

(c) $r = 2 + \sin \theta$

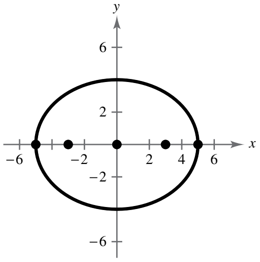
(d) $r = 2 - \cos \theta$

77. Center: $(0, 0)$

Vertices: $(\pm 5, 0)$

Foci: $(\pm 3, 0)$

Eccentricity: $\frac{3}{5}$



79. Hyperbola **81.** Ellipse

Section 10.9 *(page 763)*

1. conic **3.** Vertical

5. (a) $r = \frac{2}{1 + \cos \theta}$, parabola

(b) $r = \frac{1}{1 + 0.5 \cos \theta}$, ellipse

(c) $r = \frac{3}{1 + 1.5 \cos \theta}$, hyperbola

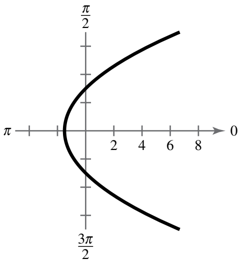
7. (a) $r = \frac{2}{1 - \sin \theta}$, parabola

(b) $r = \frac{1}{1 - 0.5 \sin \theta}$, ellipse

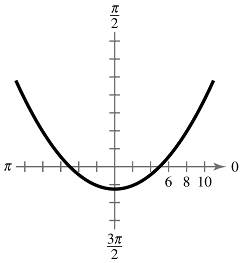
(c) $r = \frac{3}{1 - 1.5 \sin \theta}$, hyperbola

9. c **10.** d **11.** a **12.** b

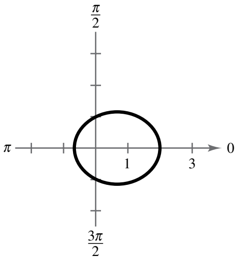
13. Parabola



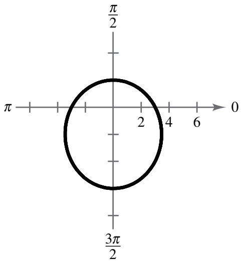
15. Parabola



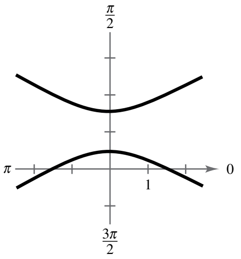
17. Ellipse



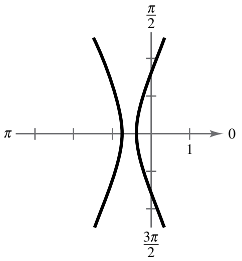
19. Ellipse



21. Hyperbola



23. Hyperbola



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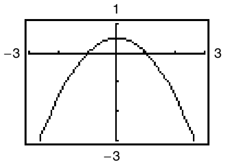
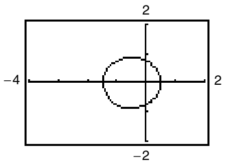


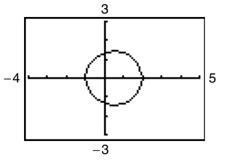
Parabola

27.



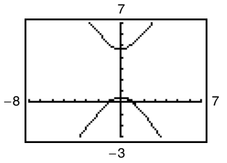
Ellipse

29.



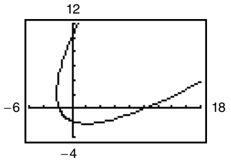
Ellipse

31.



Hyperbola

33.



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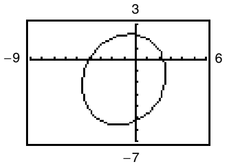


37. $r = \dfrac{1}{1 - \cos\theta}$ **39.** $r = \dfrac{3}{2 + \cos\theta}$

41. $r = \dfrac{2}{1 + 2\cos\theta}$ **43.** $r = \dfrac{4}{1 + \cos\theta}$

45. $r = \dfrac{10}{1 - \cos\theta}$ **47.** $r = \dfrac{10}{3 + 2\cos\theta}$

49. $r = \dfrac{20}{3 - 2\cos\theta}$ **51.** $r = \dfrac{9}{4 - 5\sin\theta}$

53. Answers will vary.

55. $r = \dfrac{9.2931 \times 10^7}{1 - 0.0167\cos\theta}$
Perihelion: 9.1405×10^7 mi
Aphelion: 9.4509×10^7 mi

57. $r = \dfrac{1.0821 \times 10^8}{1 - 0.0067\cos\theta}$
Perihelion: 1.0748×10^8 km
Aphelion: 1.0894×10^8 km

59. $r = \dfrac{1.4038 \times 10^8}{1 - 0.0935\cos\theta}$
Perihelion: 1.2838×10^8 mi
Aphelion: 1.5486×10^8 mi

61. $\dfrac{3}{2 + \sin\theta} = \dfrac{3/2}{1 + (1/2)\sin\theta}$, so $e = \dfrac{1}{2}$ and the conic is an ellipse.

63. True. The graphs represent the same hyperbola.

65. False. Every term in the fraction needs to be divided by 3. This yields

$$r = \frac{2}{1 - \frac{2}{3}\cos\theta}.$$

The eccentricity is $\frac{2}{3}$, so the graph is an ellipse.

67. Answers will vary.

69. $r^2 = \dfrac{24{,}336}{169 - 25\cos^2\theta}$

71. $r^2 = \dfrac{144}{25\cos^2\theta - 9}$

73. If e remains fixed and p changes, then the lengths of both the major axis and the minor axis change. For example, graph

$$r = \frac{5}{1 - \frac{2}{3}\sin\theta},$$

with $e = \frac{2}{3}$ and $p = \frac{15}{2}$, and graph

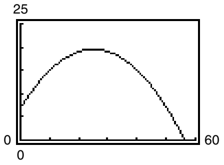
$$r = \frac{6}{1 - \frac{2}{3}\sin\theta},$$

with $e = \frac{2}{3}$ and $p = 9$, on the same set of coordinate axes.

75. $\dfrac{-7 \pm \sqrt{17}}{3}$ **77.** $-\dfrac{23}{3}, \dfrac{13}{3}$ **79.** $(-7, 0), (-1, 0)$

81. (a) $h = 7, v_0 = 40, \theta = 45°$

(b)



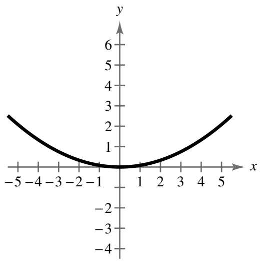
(c) Maximum height: 19.5 ft
Range: 56.2 ft

Review Exercises *(page 768)*

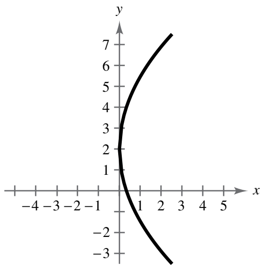
1. $\dfrac{\pi}{4}$ rad, 45° **3.** 1.9513 rad, 111.8° **5.** 0.4424 rad, 25.3°

7. 0.6588 rad, 37.7° **9.** $\dfrac{4\sqrt{5}}{5}$ **11.** Hyperbola

13. $x^2 = 12y$



15. $(y - 2)^2 = 12x$

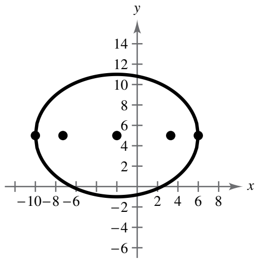


17. $y = -4x - 2$ **19.** $6\sqrt{5}$ m

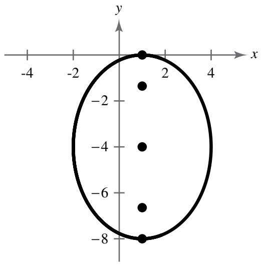
21. $\dfrac{(x - 2)^2}{9} + \dfrac{(y - 8)^2}{64} = 1$ **23.** $\dfrac{(x - 2)^2}{4} + \dfrac{(y - 1)^2}{1} = 1$

25. 3 feet from the center of the arch at ground level

27. Center: $(-2, 5)$
Vertices: $(-10, 5), (6, 5)$
Foci: $\left(-2 \pm 2\sqrt{7}, 5\right)$
Eccentricity: $e = \dfrac{\sqrt{7}}{4}$



29. Center: $(1, -4)$
Vertices: $(1, 0), (1, -8)$
Foci: $\left(1, -4 \pm \sqrt{7}\right)$
Eccentricity: $\dfrac{\sqrt{7}}{4}$



31. $\dfrac{y^2}{36} - \dfrac{x^2}{28} = 1$ **33.** $\dfrac{x^2}{16} - \dfrac{y^2}{9} = 1$

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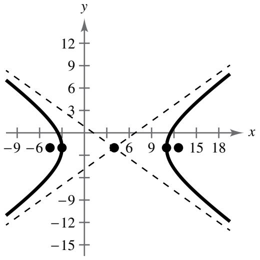
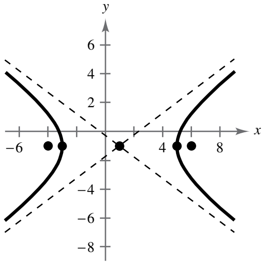
35. Center: $(4, -2)$
Vertices:
$(-3, -2), (11, -2)$
Foci: $\left(4 \pm \sqrt{74}, -2\right)$
Asymptotes:
$y = -2 \pm \frac{5}{7}(x - 4)$



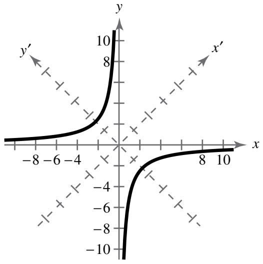
37. Center: $(1, -1)$
Vertices:
$(5, -1), (-3, -1)$
Foci: $(6, -1), (-4, -1)$
Asymptotes:
$y = -1 \pm \frac{3}{4}(x - 1)$



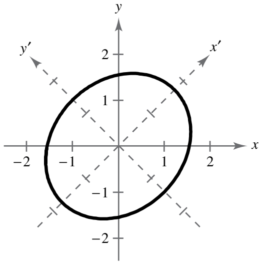
39. $\dfrac{x^2}{10{,}890{,}000} - \dfrac{y^2}{16{,}988{,}400} = 1$

41. Hyperbola **43.** Ellipse

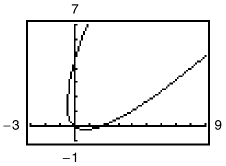
45. $\dfrac{(y')^2}{10} - \dfrac{(x')^2}{10} = 1$



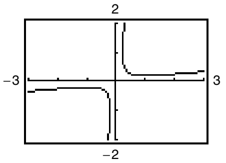
47. $\dfrac{(x')^2}{3} + \dfrac{(y')^2}{2} = 1$



49. (a) Parabola
(b) $y = \dfrac{24x + 40 \pm \sqrt{(24x + 40)^2 - 36(16x^2 - 30x)}}{18}$
(c)



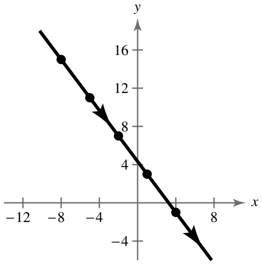
51. (a) Hyperbola (b) $y = \dfrac{10x \pm \sqrt{100x^2 - 4(x^2 + 1)}}{2}$
(c)



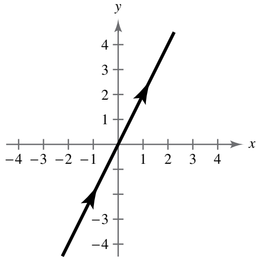
53. (a)

t	-2	-1	0	1	2
x	-8	-5	-2	1	4
y	15	11	7	3	-1

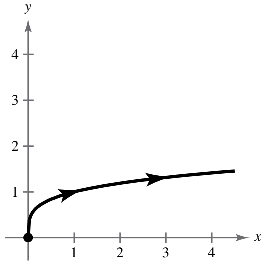
(b)



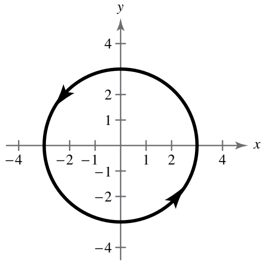
55. (a) (b) $y = 2x$



57. (a) (b) $y = \sqrt[4]{x}$



59. (a) (b) $x^2 + y^2 = 9$

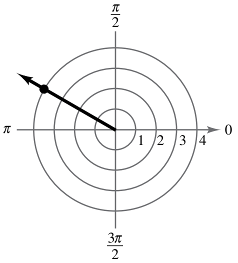


61. (a) $x = t, y = 2t + 3$
(b) $x = t - 1, y = 2t + 1$
(c) $x = 3 - t, y = 9 - 2t$

63. (a) $x = t, y = t^2 + 3$
(b) $x = t - 1, y = t^2 - 2t + 4$
(c) $x = 3 - t, y = t^2 - 6t + 12$

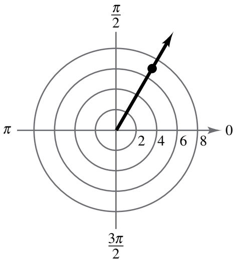
65. (a) $x = t, y = 1 - 4t^2$
(b) $x = t - 1, y = -4t^2 + 8t - 3$
(c) $x = 3 - t, y = -4t^2 + 24t - 35$

67.



$\left(4, -\dfrac{7\pi}{6}\right), \left(-4, -\dfrac{\pi}{6}\right), \left(-4, \dfrac{11\pi}{6}\right)$

69.



$(7, -5.23)$, $(7, 1.05)$, $(-7, -2.09)$

71. $(0, 0)$ **73.** $\left(-\frac{1}{2}, -\frac{\sqrt{3}}{2}\right)$ **75.** $\left(3\sqrt{2}, \frac{\pi}{4}\right)$

77. $\left(\sqrt{10}, \frac{3\pi}{4}\right)$ **79.** $r = 9$ **81.** $r = 5 \sec \theta$

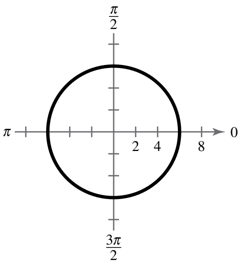
83. $r^2 = 10 \csc 2\theta$ **85.** $x^2 + y^2 = 16$

87. $x^2 + y^2 = 3x$ **89.** $x^2 + y^2 = y^{2/3}$

91. Symmetry: $\theta = \frac{\pi}{2}$, polar axis, pole

Maximum value of $|r|$: $|r| = 6$ for all values of θ

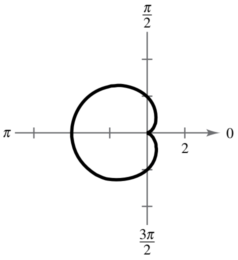
No zeros of r



93. Symmetry: polar axis

Maximum value of $|r|$: $|r| = 4$ when $\theta = 0$

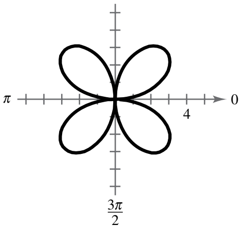
Zeros of r: $r = 0$ when $\theta = \pi$



95. Symmetry: $\theta = \frac{\pi}{2}$, polar axis, pole

Maximum value of $|r|$: $|r| = 4$ when $\theta = \frac{\pi}{4}, \frac{3\pi}{4}, \frac{5\pi}{4}, \frac{7\pi}{4}$

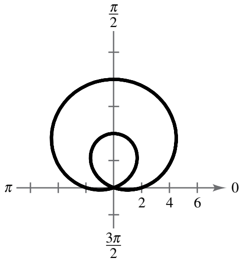
Zeros of r: $r = 0$ when $\theta = 0, \frac{\pi}{2}, \pi, \frac{3\pi}{2}$



97. Symmetry: $\theta = \frac{\pi}{2}$

Maximum value of $|r|$: $|r| = 8$ when $\theta = \frac{\pi}{2}$

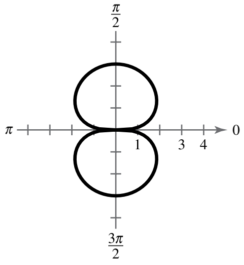
Zeros of r: $r = 0$ when $\theta = 3.4814, 5.9433$



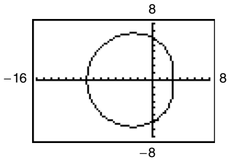
99. Symmetry: $\theta = \frac{\pi}{2}$, polar axis, pole

Maximum value of $|r|$: $|r| = 3$ when $\theta = \frac{\pi}{2}$

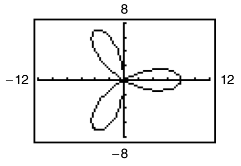
Zeros of r: $r = 0$ when $\theta = 0, \pi$



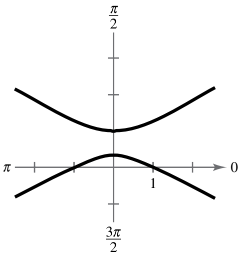
101. Limaçon



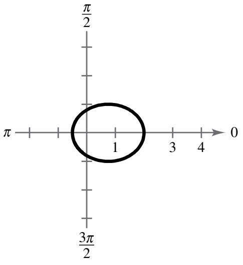
103. Rose curve



105. Hyperbola



107. Ellipse



109. $r = \dfrac{4}{1 - \cos\theta}$ **111.** $r = \dfrac{5}{3 - 2\cos\theta}$

113. $r = \dfrac{7961.93}{1 - 0.937\cos\theta}$; 10,980.11 mi

115. False. The equation of a hyperbola is a second-degree equation.
$x = t,\ y = 3 - 2t$ $\quad x = 3t,\ y = 3 - 6t$

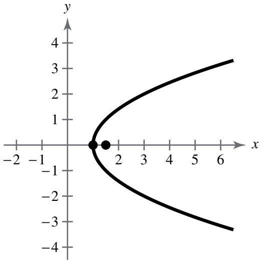
117. False. $\left(2, \dfrac{\pi}{4}\right)$, $\left(-2, \dfrac{5\pi}{4}\right)$, and $\left(2, \dfrac{9\pi}{4}\right)$ all represent the same point.

119. (a) The graphs are the same.
(b) The graphs are the same.

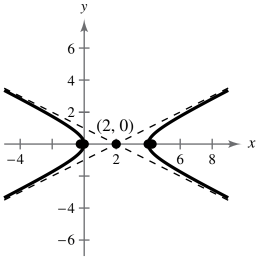
Chapter Test *(page 771)*

1. 0.5191 rad, 29.7° **2.** 0.7023 rad, 40.2° **3.** $\dfrac{\sqrt{10}}{10}$

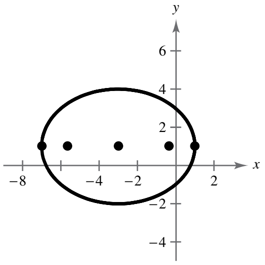
4. Parabola: $y^2 = 2(x - 1)$
Vertex: $(1, 0)$
Focus: $\left(\frac{3}{2}, 0\right)$



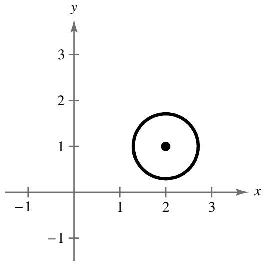
5. Hyperbola: $\dfrac{(x - 2)^2}{4} - y^2 = 1$
Center: $(2, 0)$
Vertices: $(0, 0), (4, 0)$
Foci: $\left(2 \pm \sqrt{5}, 0\right)$
Asymptotes: $y = \pm\dfrac{1}{2}(x - 2)$



6. Ellipse: $\dfrac{(x + 3)^2}{16} + \dfrac{(y - 1)^2}{9} = 1$
Center: $(-3, 1)$
Vertices: $(1, 1), (-7, 1)$
Foci: $\left(-3 \pm \sqrt{7}, 1\right)$

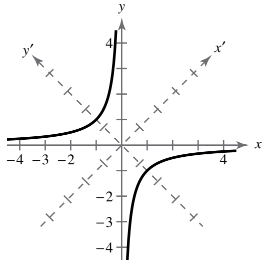


7. Circle: $(x - 2)^2 + (y - 1)^2 = \frac{1}{2}$
Center: $(2, 1)$

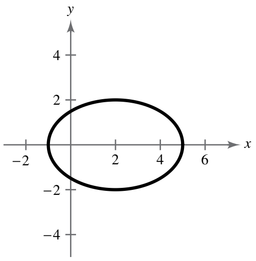


8. $(y + 4)^2 = 12(x - 3)$ **9.** $\dfrac{y^2}{2/41} - \dfrac{x^2}{162/41} = 1$

10. (a) $\dfrac{(y')^2}{2} - \dfrac{(x')^2}{2} = 1$
(b)



11. $\dfrac{(x - 2)^2}{9} + \dfrac{y^2}{4} = 1$



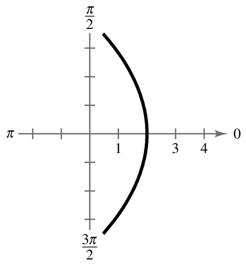
12. (a) $x = t,\ y = 3 - t^2$
(b) $x = t - 2,\ y = -t^2 + 4t - 1$

13. $\left(\sqrt{3}, -1\right)$

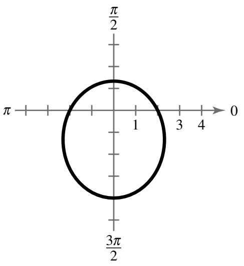
14. $\left(2\sqrt{2}, \dfrac{7\pi}{4}\right), \left(-2\sqrt{2}, \dfrac{3\pi}{4}\right), \left(2\sqrt{2}, -\dfrac{\pi}{4}\right), \left(-2\sqrt{2}, -\dfrac{5\pi}{4}\right)$

15. $r = 8$

16. Parabola



17. Ellipse



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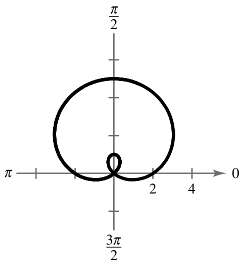
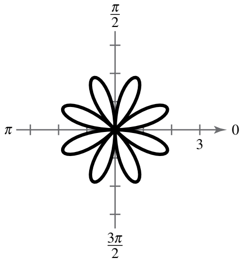
18. Limaçon with inner loop



19. Rose curve



20. Answers will vary. For example: $r = \dfrac{1}{1 + 0.25 \sin \theta}$

21. Slope: 0.1511; Change in elevation: 789 ft

22. No; Yes

Problem Solving *(page 775)*

1. (a) 1.2016 rad (b) 2420 ft, 5971 ft

3. $A = \dfrac{4a^2b^2}{a^2 + b^2}$

5. (a) Because $d_1 + d_2 \leq 20$, by definition, the outer bound that the boat can travel is an ellipse. The islands are the foci.

(b) Island 1: $(-6, 0)$; Island 2: $(6, 0)$

(c) 20 mi; Vertex: $(10, 0)$

(d) $\dfrac{x^2}{100} - \dfrac{y^2}{64} = 1$

7. Proof

9. Proof

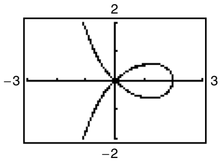
11. Answers will vary. *Sample answer:*

$x = \cos(-t)$
$y = 2 \sin(-t)$

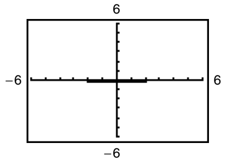
13. (a) $y^2 = x^2\left(\dfrac{2 - x}{2 + x}\right)$

(b) $x = \dfrac{2 - 2t^2}{1 + t^2}, y = \dfrac{t(2 - 2t^2)}{1 + t^2}$

(c)

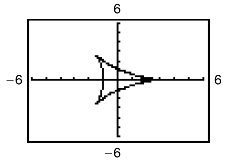


15. (a)



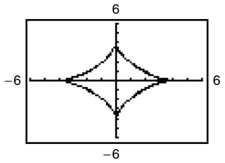
The graph is a line between -2 and 2 on the x-axis.

(b)



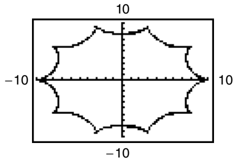
The graph is a three-sided figure with counterclockwise orientation.

(c)



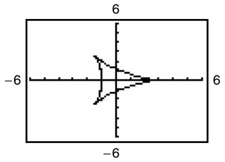
The graph is a four-sided figure with counterclockwise orientation.

(d)



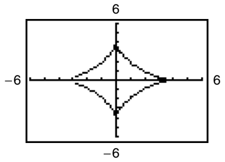
The graph is a 10-sided figure with counterclockwise orientation.

(e)



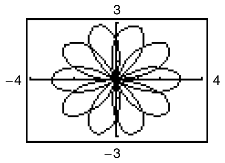
The graph is a three-sided figure with clockwise orientation.

(f)

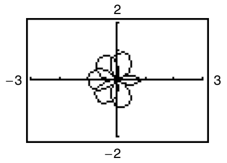


The graph is a four-sided figure with clockwise orientation.

17.



$r = 3 \sin\left(\dfrac{5\theta}{2}\right)$



$r = -\cos\left(\sqrt{2}\theta\right)$,
$-2\pi \leq \theta \leq 2\pi$

Sample answer: If n is a rational number, then the curve has a finite number of petals. If n is an irrational number, then the curve has an infinite number of petals.

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Chapter 11

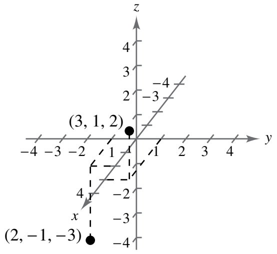
Section 11.1 *(page 783)*

1. three-dimensional **3.** surface; space

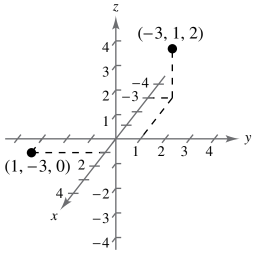
5. *xy*-plane, *xz*-plane, *yz*-plane

7. Use the Distance Formula in Space:
$d = \sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2 + (z_2 - z_1)^2}$.

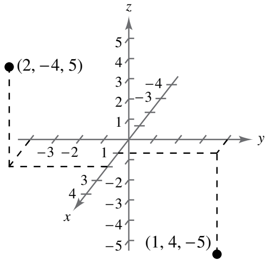
9.



11.



13.



15. $(-2, 4, 3)$ **17.** $(0, -3, 5)$ **19.** Octant IV

21. Octants II, IV, VI, and VIII **23.** $\sqrt{33}$ units

25. $\sqrt{29}$ units **27.** $\sqrt{110}$ units **29.** 12 units

31. $\sqrt{114}$ units **33.** $\left(2\sqrt{5}\right)^2 + 3^2 = \left(\sqrt{29}\right)^2$

35. $6, 6, 2\sqrt{10}$; isosceles triangle

37. $6, 6, 2\sqrt{10}$; isosceles triangle **39.** $\left(\frac{5}{2}, -3, 2\right)$

41. $(0, -1, 7)$ **43.** $\left(\frac{1}{2}, \frac{1}{2}, -1\right)$ **45.** $\left(\frac{5}{2}, 2, 6\right)$

47. $(x - 3)^2 + (y - 2)^2 + (z - 4)^2 = 16$

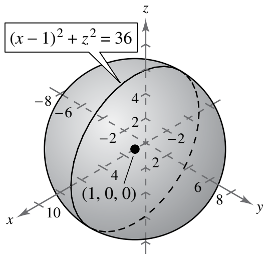
49. $\left(x - \frac{3}{2}\right)^2 + y^2 + (z - 3)^2 = \frac{45}{4}$

51. Center: $(3, 0, 0)$; radius: 3

53. Center: $(2, -1, 3)$; radius: 2

55. Center: $\left(\frac{1}{3}, -1, 0\right)$; radius: 1

57.



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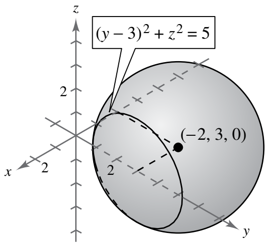

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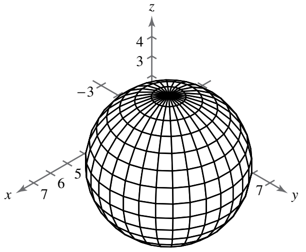


63. $x^2 + y^2 + z^2 = \dfrac{205^2}{4}$

65. False. *z* is the directed distance from the *xy*-plane to *P*.

67. 0; 0; 0 **69.** $(x_2, y_2, z_2) = (2x_m - x_1, 2y_m - y_1, 2z_m - z_1)$

71. 10; 126.87° **73.** 4; 60° **75.** $\langle 69, 138\rangle$; vector

77. 1; scalar

Section 11.2 *(page 790)*

1. zero **3.** component form

5. $\|\mathbf{v}\| = \sqrt{v_1^2 + v_2^2 + v_3^2}$ **7.** $\langle 0, 6, 0\rangle$ **9.** $\langle 7, -5, 7\rangle$

11. $3\sqrt{5}$ **13.** $\sqrt{11}$ **15.** $\sqrt{74}$ **17.** $\sqrt{34}$

19. (a) $\dfrac{\sqrt{29}}{29}\langle 2, 0, 5\rangle$ (b) $-\dfrac{\sqrt{29}}{29}\langle 2, 0, 5\rangle$

21. (a) $\dfrac{\sqrt{74}}{74}(8\mathbf{i} + 3\mathbf{j} - \mathbf{k})$ (b) $-\dfrac{\sqrt{74}}{74}(8\mathbf{i} + 3\mathbf{j} - \mathbf{k})$

23. -4 **25.** 0 **27.** About 124.45°

29. About 109.92° **31.** Parallel **33.** Orthogonal

35. Not collinear **37.** Collinear **39.** $(3, 1, 7)$

41. $\pm\dfrac{3\sqrt{14}}{14}$ **43.** $\left\langle 0, 2\sqrt{2}, 2\sqrt{2}\right\rangle$ or $\left\langle 0, 2\sqrt{2}, -2\sqrt{2}\right\rangle$

45. *B*: 226.52 N, *C*: 202.92 N, *D*: 157.91 N

47. True. When $0° \le \theta \le 180°$ and $\cos\theta = 0$, $\theta = 90°$.

49. $-3\mathbf{u} = \mathbf{v}$, so the points are collinear.

51. The angle between **u** and **v** is an obtuse angle. **53.** 9

55. 71 **57.** 10 **59.** 25**61.** 10 **63.** 2

Section 11.3 *(page 797)*

1. cross product

3. **u** and **v** are scalar multiples of each other.

5. $-\mathbf{i} + 7\mathbf{j} + 5\mathbf{k}$ **7.** $\mathbf{0}$ **9.** $-2\mathbf{i} + 14\mathbf{j} + 10\mathbf{k}$

11. $\mathbf{i} - 7\mathbf{j} - 5\mathbf{k}$ **13.** 0 **15.** $\langle 1, 1, 1\rangle$ **17.** $\langle -2, 3, 3\rangle$

19. $-17\mathbf{i} + \mathbf{j} + 10\mathbf{k}$ **21.** $-7\mathbf{i} + 13\mathbf{j} + 16\mathbf{k}$

23. $-\mathbf{i} - 2\mathbf{j} - \mathbf{k}$ **25.** $\frac{1}{3}\mathbf{i} - \frac{2}{3}\mathbf{j} - \frac{2}{3}\mathbf{k}$

27. $\dfrac{\sqrt{19}}{19}(\mathbf{i} - 3\mathbf{j} + 9\mathbf{k})$ **29.** $\dfrac{\sqrt{2}}{2}(\mathbf{i} - \mathbf{j})$

31. $\dfrac{\sqrt{5}}{15}(4\mathbf{i} + 5\mathbf{j} + 2\mathbf{k})$ **33.** 56 **35.** 1 **37.** $30\sqrt{3}$

39. (a) Answers will vary. (b) $6\sqrt{10}$

41. (a) Answers will vary. (b) $\sqrt{286}$

43. $\dfrac{3\sqrt{13}}{2}$ **45.** $\dfrac{1}{2}\sqrt{4290}$ **47.** 6 **49.** 2 **51.** 2

53. 12 **55.** 84 **57.** (a) $T = \dfrac{p}{2}\cos 40°$

(b)

p	15	20	25	30	35	40	45
T	5.75	7.66	9.58	11.49	13.41	15.32	17.24

59. True. The cross product is not defined for two-dimensional vectors.

61. Proof **63.** $\dfrac{\sqrt{10}}{10} \approx 0.3162$ **65.** $y = 3x - 3$

67. $y = 2x + 19$

Section 11.4 *(page 806)*

1. direction **3.** Perpendicular

5. (a) $x = 4 + 5t,\ y = 1 + 3t,\ z = 2 + 6t$

(b) $\dfrac{x-4}{5} = \dfrac{y-1}{3} = \dfrac{z-2}{6}$

7. (a) $x = 2 + 4t,\ y = -5 + 3t,\ z = -t$

(b) $\dfrac{x-2}{4} = \dfrac{y+5}{3} = -z$

9. (a) $x = 2 + 2t,\ y = -3 - 3t,\ z = 5 + t$

(b) $\dfrac{x-2}{2} = \dfrac{y+3}{-3} = z - 5$

11. (a) $x = 2 - t,\ y = 4t,\ z = 2 - 5t$

(b) $\dfrac{x-2}{-1} = \dfrac{y}{4} = \dfrac{z-2}{-5}$

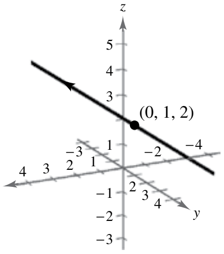
13. (a) $x = -3 + 4t,\ y = 8 - 10t,\ z = 15 + t$

(b) $\dfrac{x+3}{4} = \dfrac{y-8}{-10} = z - 15$

15. (a) $x = 3 - 4t,\ y = 1,\ z = 2 + 3t$

(b) No symmetric equations

17.



19. $-2x + y - 2z + 10 = 0$ **21.** $-2x + y + 2z - 3 = 0$

23. $-2x - 4y + 3z + 4 = 0$ **25.** $6x - 2y - z - 8 = 0$

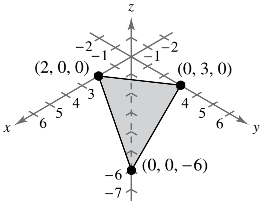
27. $y - 5 = 0$ **29.** $y - z + 2 = 0$ **31.** Perpendicular

33. Parallel **35.** Neither; about 61.6°

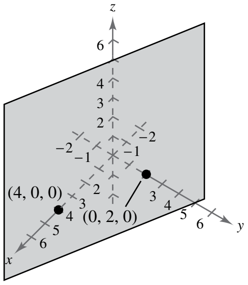
37. $x = 2$
$y = 3$
$z = 4 + t$

39. (a) 56.9° (b) $x = t,\ y = -7t,\ z = -3t$

41.



43.



45. $\dfrac{3\sqrt{5}}{5}$ **47.** $\dfrac{10\sqrt{17}}{17}$ **49.** 89.1°

51. False. Lines that do not intersect and are not in the same plane may not be parallel.

53. The parametric equations should be $x = -2 - 3t,\ y = 5 - 4t$, and $z = 3 + 2t$.

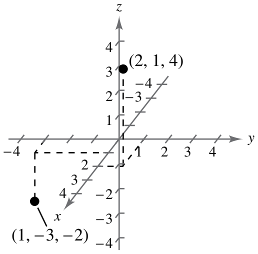
55. (a) 243 (b) -1

57. All real numbers x except $x = -3$; $f(x) \to \infty$ as $x \to -3^-$, $f(x) \to -\infty$ as $x \to -3^+$

59. All real numbers x except $x = \pm 2$; $f(x) \to \infty$ as $x \to -2^-$, $f(x) \to -\infty$ as $x \to -2^+$, $f(x) \to -\infty$ as $x \to 2^-$, $f(x) \to \infty$ as $x \to 2^+$

Review Exercises *(page 810)*

1.



3. $(-5, 4, 0)$ **5.** $\sqrt{41}$ **7.** $\sqrt{61}$

9. $\sqrt{29},\ \sqrt{38},\ \sqrt{67}$
$\left(\sqrt{29}\right)^2 + \left(\sqrt{38}\right)^2 = \left(\sqrt{67}\right)^2$

11. $(5, 4, 5)$ **13.** $(-2, 2, 2)$

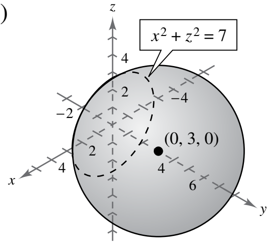
15. $(x - 1)^2 + (y - 5)^2 + (z - 4)^2 = 4$

17. $(x - 1)^2 + (y + 4)^2 + (z - 2)^2 = 49$

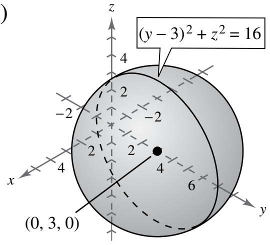
19. $x^2 + y^2 + z^2 = 12$ **21.** Center: $(0, 0, 4)$; radius: 4

23. Center: $(5, -3, 2)$; radius: 2

25. (a)



(b)



27. (a) $\langle 1, 6, -1\rangle$ (b) $\sqrt{38}$ (c) $\left\langle \dfrac{\sqrt{38}}{38}, \dfrac{3\sqrt{38}}{19}, -\dfrac{\sqrt{38}}{38}\right\rangle$

29. (a) $\langle -10, 6, 7\rangle$ (b) $\sqrt{185}$

(c) $\left\langle \dfrac{-2\sqrt{185}}{37}, \dfrac{6\sqrt{185}}{185}, \dfrac{7\sqrt{185}}{185}\right\rangle$

31. -9 **33.** 1 **35.** About 77.83° **37.** Parallel

39. Orthogonal **41.** Collinear **43.** Not collinear

45. A: 159.1 lb
B: 115.6 lb
C: 115.6 lb

47. $\langle -10, 0, -10\rangle$ **49.** $4\mathbf{i} + 2\mathbf{j} - 7\mathbf{k}$

51. $\dfrac{\sqrt{11}}{11}\mathbf{i} + \dfrac{3\sqrt{11}}{11}\mathbf{j} + \dfrac{\sqrt{11}}{11}\mathbf{k}$

53. $-\dfrac{71\sqrt{7602}}{7602}\mathbf{i} - \dfrac{22\sqrt{7602}}{3801}\mathbf{j} + \dfrac{25\sqrt{7602}}{7602}\mathbf{k}$

55. (a) Answers will vary. (b) $2\sqrt{43}$ **57.** 75

59. (a) $x = -2t,\ y = 5t,\ z = t$

(b) $\dfrac{x}{-2} = \dfrac{y}{5} = z$

61. (a) $x = -1 + 4t,\ y = 3 + 3t,\ z = 5 - 6t$

(b) $\dfrac{x+1}{4} = \dfrac{y-3}{3} = \dfrac{z-5}{-6}$

63. $-2x - 12y + 5z = 0$ **65.** $z - 2 = 0$

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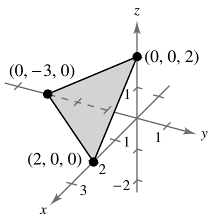
67.



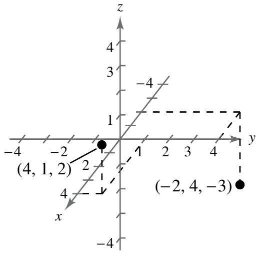
69. $\dfrac{\sqrt{6}}{6}$ **71.** $\dfrac{27\sqrt{17}}{17}$

73. False. $c(\mathbf{u} \times \mathbf{v}) = (c\mathbf{u}) \times \mathbf{v} = \mathbf{u} \times (c\mathbf{v})$

75. Answers will vary.

Chapter Test *(page 812)*

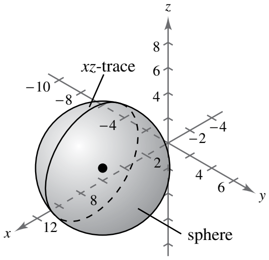
1.



2. (8, 0, 0)

3. No. $(\sqrt{76})^2 + (\sqrt{102})^2 \neq (\sqrt{194})^2$ **4.** (7, 1, 2)

5. $(x - 7)^2 + (y - 1)^2 + (z - 2)^2 = 19$



6. $\mathbf{u} = \langle -2, 6, -6 \rangle$, $\mathbf{v} = \langle -12, 5, -5 \rangle$

7. (a) 84 (b) $\langle 0, 62, 62 \rangle$

8. (a) $\left\langle -\dfrac{\sqrt{19}}{19}, \dfrac{3\sqrt{19}}{19}, -\dfrac{3\sqrt{19}}{19} \right\rangle$

(b) $\left\langle -\dfrac{6\sqrt{194}}{97}, \dfrac{5\sqrt{194}}{194}, -\dfrac{5\sqrt{194}}{194} \right\rangle$

9. 46.23°

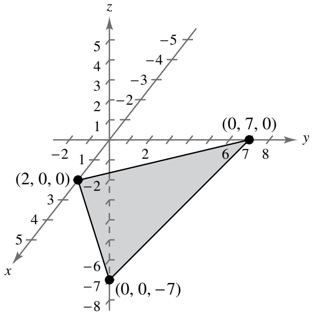
10. (a) $x = 8 - 2t, y = -2 + 6t, z = 5 - 6t$

(b) $\dfrac{x - 8}{-2} = \dfrac{y + 2}{6} = \dfrac{z - 5}{-6}$

11. Parallel **12.** Orthogonal

13. (a) Answers will vary. (b) $2\sqrt{230}$ **14.** 200

15.



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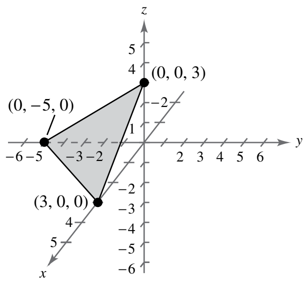
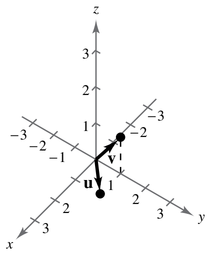


17. $11x + 4y + 16z + 6 = 0$ **18.** $\dfrac{4\sqrt{14}}{7}$

19. About 88.5°

Problem Solving *(page 815)*

1. (a)



(b) Answers will vary.

(c) $a = b = 1$ (d) Answers will vary.

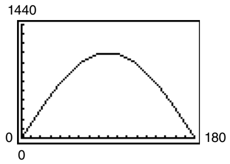
3. (a) Right triangle (b) Obtuse triangle

(c) Obtuse triangle (d) Acute triangle

5. About 860.0 lb **7.** Answers will vary.

9–11. Proofs

13. (a) $1080 \sin \theta$



(b) $540\sqrt{2} \approx 763.48$

(c) $\theta = 90°$. This is what should be expected. When $\theta = 90°$, the pipe wrench is horizontal.

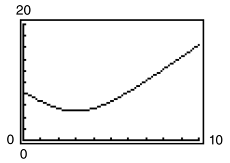
15. Proof

17. (a) $D = \dfrac{3\sqrt{2}}{2}$

(b) $D = \sqrt{5}$

19. (a) $d = \sqrt{70} \approx 8.4$ in.

(b)



(c) The distance between the two insects appears to lessen in the first 3 minutes but then begins to increase.

(d) The insects get within 5 inches of each other.